SOIL SURVEY OF BENTON COUNTY AREA, WASHINGTON

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THE BENTON COUNTY AREA is in the lower Yakima Valley, in the south-central part of the State (fig. 1). It includes all of Benton County except the northeastern quarter. The area surveyed makes up approximately 810,293 acres, or about 1,266 square miles. Of this acreage, about 106,723 acres, used mainly for irrigated crops, was surveyed at high intensity. The rest, used mainly for dryland crops and for range, was surveyed at medium intensity.

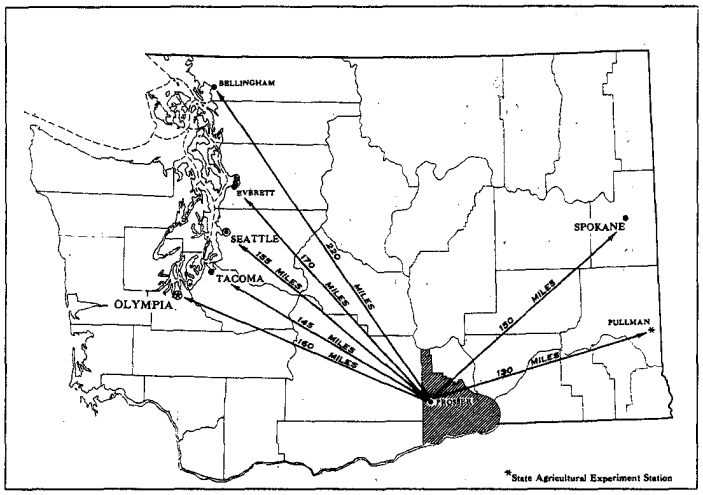

Figure 1.-Location of Benton County Area in Washington.

Prosser, the county seat, is in the west-central part of Benton County. The Columbia River forms all of the: southern boundary of the Area and part of the eastern boundary. The Yakima River flows in a generally easterly direction through the central part of Benton County and empties into the Columbia River.

How This Soil Survey Was Made

Soil scientists made this survey to learn what kinds of soils are in the Benton County Area,, where they are located, and how they can be used. They went into the area knowing they would likely find many soils they had already seen, and perhaps some they had not. As they traveled over the Area, they observed steepness, length, and shape of slopes; size and speed of streams; kinds of native plants or crops; kinds of rock; and many facts about the soils. They dug many holes to expose soil profiles. A profile is the sequence of natural layers, or horizons, in a soil; it extends from the surface down into the parent material that has not been changed much by leaching or by roots of plants.

The soil scientists made comparisons among the profiles they studied, and they compared these profiles with those in counties nearby and in places more distant. They classified and named the soils according to nationwide, uniform procedures. The categories of the classification most used in a local survey are the soil series and the soil phase.

Soils that have profiles almost alike make up a soil series (12). Except for different texture in the surface layer, the major horizons of all the soils of one series are similar in thickness, arrangement, and other important characteristics. Each soil series is named for a town or other geographic feature near the place where a soil of that series was first observed and mapped. Ritzville and Prosser, for example, are the names of two soil series. All the soils in the United States having the same series name are essentially alike in natural characteristics.

Soils of one series can differ in texture of their surface layer and in slope, stoniness, or some other characteristic that affects use of the soils by man. On the basis of such differences, a soil series is divided into phases. The name of a soil phase indicates a feature that affects management. For example, Ritzville silt loam, 0 to 5 percent slopes, is one of several phases within the Ritzville series.

After a guide for classifying and naming the soils had been worked out, the soil scientists drew the boundaries of the individual soils on aerial photographs. These photographs show buildings, field borders, trees, and other details that help in drawing boundaries accurately. The soil map at the back of this publication was prepared from aerial photographs.

The areas shown on a soil map are called mapping units. On most maps detailed enough to be useful in plan-

Italicized numbers in parentheses refer to Literature Cited

ning management of farms and fields, a mapping unit is nearly equivalent to a soil type or a phase. It is not exactly equivalent, because it is not practical to show on such a map all the small, scattered bits of soil of some other kind that have been seen within an area that is dominantly of a recognized soil phase.

Most surveys include areas where the soil material is so rocky, so shallow, or so frequently worked by wind and water that it cannot be classified by soil series. These areas are shown on the map like other mapping units, but they are given descriptive names, such as Dune land, and are called land types.

While a soil survey is in progress, samples of soils are taken, as needed, for laboratory measurements and for engineering tests. Laboratory data from the same kinds of soils in other places are assembled. Data on yields of crops under defined practices are assembled from farm records and from field or plot experiments on the same kinds of soils. Yields under defined management are estimated for those soils that are suitable for cultivation.

But only part of a soil survey is done when the soils have been named, described, and delineated on the map, and the laboratory data and yield data have been assembled. The mass of detailed information then needs to be organized in such a way that it is readily useful to different groups of readers, among them farmers, ranchers, managers of woodland, engineers, and homeowners. Grouping soils that are similar in suitability for each specified use is the method of organization commonly used in soil surveys. On the basis of yield and practice tables and other data, the soil scientists set up trial groups. They test these groups by further study and by consultation with farmers, agronomists, engineers, and others, and then adjust the groups according to the results of their studies and consultation. Thus, the groups that are finally evolved reflect up-to-date knowledge of the soils and their behavior under methods of use and management current at the time of this survey.

General Soil Map

The general soil map shows, in color, the soil associations in the Benton County Area. A soil association is a landscape that has a distinctive proportional pattern of soils. It normally consists of one or more major soils and at least one minor soil, and it is named for the major soils. The soils in one association may occur in another, but in a different pattern.

A map showing soil associations is useful to people who want a general idea of the soils in an Area, who want to compare different parts of an Area, or who want to know the location of large tracts that are suitable for a certain kind of land use. Such a map is a useful general guide in managing a watershed, a wooded tract, or a wildlife area, or in planning engineering works, recreational facilities, and community developments. It is not a suitable map for planning the management of a farm or field, or for selecting the exact location of a road, building, or similar structure, because the soils in any one association ordinarily differ in slope, depth, stoniness, drainage, and other characteristics that affect their management.

The soil associations in the Benton County Area are discussed in the following pages.

1. Ritzville-Willis association

Gently sloping soils that are silt loam throughout and very deep to shallow over basalt bedrock; formed in loess; precipitation zone 9 to 12 inches

This association occurs mainly in the higher part of Horse Heaven Hills and midway up the slopes in the Rattlesnake Hills. The topography is generally smooth and gently sloping, but steeper areas along the larger drainageways are included. The soils formed in silty, wind deposited material (loess). They are generally underlain by basalt bedrock at a depth of more than 40 inches. The parent material on the uplands included a small amount of volcanic ash. The annual precipitation is 9 to 12 inches, the mean annual temperature is approximately 48° F., and the frost-free season is about 140 days. Elevations range from 1,200 to 2,500 feet. This association makes up about 31 percent of the Area.

Ritzville soils make up about 80 percent of the association. Willis soils make up about 10 percent, and Ellisforde, Esquatzel, and Kiona soils make up the rest. The soils are well drained.

This association is used mainly for wheat, barley, and rye in a summer-fallow system. Soils that are shallow, stony, or steep are used for grazing. The vegetation in uncultivated areas is grass and sagebrush. An average farm has about 2,400 acres of cultivated land. The population is sparse.

2. Warden-Shano association

Gently sloping soils that are silt loam throughout and very deep to moderately deep over basalt bedrock; formed in lacustrine material and loess; precipitation zone 6 to 9 inches

This association occurs mainly midway up the slopes of Horse Heaven Hills, in the lower Rattlesnake Hills, and in the vicinity of Kiona. The topography is generally smooth and gently sloping but is steeper along the larger drainageways. The soils formed mainly in reworked lacustrine material and in silty, wind deposited material (loess). The parent material on the uplands included a small amount of volcanic ash. The annual precipitation is 6 to 9 inches, the mean annual temperature is approximately 50°F., and the frost-free season is about 150 days. Elevations range from 550 to 1,200 feet. This association makes up about 31 percent of the Area.

Warden soils make up about 65 percent of the association, Shano soils make up 25 percent, and Burke, Esquatzel, and Kiona soils make up the rest. These soils are well drained. In places they are shallow or moderately deep over a cemented lime-silica hardpan that overlies basalt.

This association is used mainly for wheat, barley, and rye in a summer-fallow system. Approximately 18 percent of it is within irrigation districts. The Warden and Shano soils are highly productive, and many crops are suitable. Soils that are shallow, stony, or too steep for cultivation are used for grazing. The vegetation is grass and sagebrush. In nonirrigated areas, an average farm has about 2,500 acres in cultivation. These areas are sparsely populated. In irrigated areas, an average farm covers about 160 acres. Most owners of irrigated farms

live on their farms, and many provide housing for farm laborers.

3. Walla Walla-Endicott-Lickskillet association

Gently sloping soils that are silt loam throughout and very deep to shallow over basalt bedrock; formed in loess; precipitation zone 11 to 15 inches

This association occurs mainly in the higher parts of the Rattlesnake Hills. The topography is generally smooth and gently sloping, but steeper areas along the larger drainageways are included. The soils formed in silty, wind-deposited material (loess). They are generally underlain by basalt bedrock. In some places the bedrock is capped with a cemented lime-silica hardpan. The annual precipitation is 11 to 15 inches, the mean annual temperature is approximately 47°F., and the frost-free season is about 130 days. Elevations range from 2,200 to 3,500 feet. This association makes up about 4 percent of the Area.

The deep Walla Walla soils make up about 42 percent of the association. Shallow to moderately deep Endicott soils make up about 30 percent, and very stony Lickskillet soils make up about 28 percent. The soils are well drained.

This association is used mainly for wheat, barley, and rye in a summer-fallow system. Soils that are shallow, stony, or steep are used for grazing. The vegetation in uncultivated areas is grass and sagebrush. An average farm has about 2,200 acres of cultivated land. The population is sparse.

4. Starbuck-Scooteney association

Gently sloping soils that are silt loam throughout and shallow to very deep over gravel or basalt bedrock; formed in old alluvium and loess; precipitation zone 6 to 9 inches

This association occurs mainly along the Yakima River. The topography is generally smooth and gently sloping, but some basalt escarpments are included. The soils formed in old alluvium and silty, wind-deposited material (loess). Starbuck soils are shallow over basalt bedrock; Scooteney soils are underlain by gravelly deposits. The annual precipitation is 6 to 9 inches, the mean annual temperature is approximately 50°F., and the frost-free season is about 155 days. Elevations range from 500 to 1,000 feet. This association makes up about 5 percent of the Area.

Starbuck soils make up about 40 percent of the association, and Scooteney soils, about 30 percent. Also in this association are Wamba soils, which make up about 8 percent; Esquatzel soils, which make up 5 percent; and small acreages of Burbank, Burke, Finley, Prosser, and Warden soils, which make up the rest. The soils are mainly well drained, but a few areas are somewhat poorly drained.

Except for areas that are too stony or too steep, most of this association is irrigated. Starbuck and Wamba soils are used mainly for hay and pasture. Scooteney soils are used for tree fruits and grapes, as well as for hay and pasture. The vegetation in uncultivated areas is grass and sagebrush. An average farm covers about 40 acres. Many of the farmers work at part-time jobs off the farm.

5. Kiona-Ritzville association

Steep soils that are silt loam throughout and very deep to shallow over basalt rubble or bedrock; formed in loess and residuum; precipitation zone 6 to 12 inches

This association occupies bluffs that extend from Horse Heaven Hills to the Columbia River and areas along the Yakima River. The topography is rough and steep; rock outcrops and escarpments are common. The soils formed in silty, wind-deposited material, and basalt residuum. They are underlain by basalt rubble and basalt bedrock. The annual precipitation is 6 to 12 inches, the mean annual temperature is approximately 49°F., and the frost-free season is about 147 days. Elevations range from 800 to 2,500 feet. This association makes up about 4 percent of the Area.

The very stony Kiona soils make up about 85 percent of the association, and Ritzville and Shano soils make up about 10 percent. Small acreages of Scooteney soils and of Rock outcrop make up the rest. The soils are well drained.

This association is used for grazing and for wildlife habitat. The vegetation is mainly grass and sagebrush. There are no homes in this association.

6. Hezel-Quincy-Burbank association

Gently sloping soils that have a loamy sand surface layer and are very deep to shallow over gravel, lacustrine material, or basalt bedrock; formed in windblown sand, lacustrine material, or alluvium; precipitation zone 6 to 9 inches

This association occurs as two main areas: one area is in the southern part of Benton County along the Columbia River, and the other is northwest of Kennewick and south of the Horn and the Yakima Rivers. The topography is smooth and gently sloping. The soils formed in windblown sand, loamy sand, or alluvium, or in a combination of these materials. They are generally very deep, but in places they are shallow over basalt bedrock or a cemented lime-silica hardpan. The annual precipitation is 6 to 9 inches, the mean annual temperature is approximately 51°F., and the frost-free season is about 170 days. Elevations range from 300 to 900 feet. This association makes up about 21 percent of the Area.

Hezel soils make up about 30 percent of the association, Quincy soils about 29 percent, and Burbank soils about 16 percent. Also in this association are small acreages of Koehler and Pasco soils and of miscellaneous land types. The soils are mainly excessively drained or somewhat excessively drained, but some areas near the rivers are poorly drained.

Most of this association is used for range. The vegetation is mainly grass and sagebrush. Small areas near Benton City and West Richland are used for irrigated hay and pasture. The population is sparse.

7. Scooteney-Kennewick association

Gently sloping, very deep soils that are silt loam throughout; formed in old alluvium and lacustrine material; precipitation zone 6 to 9 inches

This association, which includes the city of Kennewick, occurs in the southeastern part of the Area. The topography is mainly smooth and gently sloping. The soils

formed in lacustrine sediments and in old alluvium. The annual precipitation is 6 to 9 inches, the mean annual temperature is approximately 50°F., and the frost-free season is about 150 days. Elevations range from 550 to 800 feet. This association makes up about 2 percent of the Area.

Scooteney soils make up about 40 percent of the association, and Kennewick soils, about 25 percent. Small acreages of Burbank, Finley, Pasco, and Warden soils make up the rest. The soils are well drained and very deep.

This association is used for many kinds of irrigated crops. The vegetation in uncultivated areas is mainly grass and sagebrush. An average farm covers about 160 acres.

8. Finley-Burbank-Quincy association

Nearly level soils that are loamy sand to very fine sand throughout; formed in old alluvium and windblown sand; precipitation zone 6 to 9 inches

This association occurs in the southeastern part of the Area, along the Columbia River. It is generally east of Kennewick. The topography is mainly smooth and nearly level. The soils formed in coarse textured and moderately coarse textured old alluvium, windblown sand, or a combination of these materials. The annual precipitation is 6 to 9 inches, the mean annual temperature is approximately 51°F., and the frost-free season is about 160 days. Elevations range from 350 to 450 feet. This association makes up about 2 percent of the Area.

Finley, Burbank, and Quincy soils make up approximately equal parts of the association; soils of each series constitute about 30 percent of the acreage. Small acreages of Pasco and Hezel soils and of miscellaneous land types make up the rest. The soils are mainly well drained or excessively drained, but there are a few somewhat poorly drained areas.

Most of this association is irrigated and used for hay and pasture. A few areas are used for grapes, mint, asparagus, and other crops. The vegetation in uncultivated areas is grass and sagebrush. An average farm has about 50 acres. Many of the residents have jobs in town and farm part time.

Use and Management of the Soils

This section explains the system of capability classification used by the Soil Conservation Service. It describes the irrigated and dryland capability units into which the soils of the Area have been classified, and it contains a section on estimated yields of both irrigated and dryland crops.

This section also groups the soils according to their suitability for range and for wildlife habitat, and it discusses the use of the soils for windbreaks. In addition, it contains a section that gives information about soil characteristics significant in engineering.

Capability Grouping

Capability grouping shows, in a general way, the suitability of soils for most kinds of field crops. The soils are grouped according to their limitations when used for field crops, the risk of damage when they are used, and the way they respond to treatment. The grouping does not take into account major and generally expensive land-forming that would change slope, depth, or other characteristics of the soils; does not take into consideration possible but unlikely major reclamation projects; and does not apply to rice, cranberries, horticultural crops, or other crops requiring special management.

Those familiar with the capability classification can infer from it much about the behavior of soils when used for other purposes, but this classification is not a substitute for interpretations designed to show suitability and limitations of groups of soils for range, for forest trees, or engineering.

In the capability system, the kinds of soils are grouped at three levels: the capability class, the subclass, and the unit. These are discussed in the following paragraphs.

CAPABILITY CLASSES, the broadest groups, are designated by Roman numerals I through VIII. The numerals indicate progressively greater limitations and narrower choices for practical use, defined as follows

Class I soils have few limitations that restrict their use.

Class II soils have moderate limitations that reduce the choice of plants or that require moderate conservation practices.

Class III soils have severe limitations that reduce the choice of plants, require special conservation practices, or both.

Class IV soils have very severe limitations that reduce the choice of plants, require very careful management, or both.

Class V soils are subject to little or no erosion but have other limitations, impractical to remove, that limit their use largely to pasture, range, woodland, or wildlife habitat. (None of the soils of the Benton County Area are in class V.)

Class VI soils have severe limitations that make them generally unsuited to cultivation and limit their use largely to pasture or range, woodland, or wildlife habitat.

Class VII soils have very severe limitations that make them unsuited to cultivation and that restrict their use largely to pasture or range, woodland, or wildlife habitat.

Class VIII soils and landforms have limitations that preclude their use for commercial plant production and restrict their use to recreation, wildlife habitat, or water supply, or to esthetic purposes.

CAPABILITY SUBCLASSES are soil groups within one class; they are designated by adding a small letter, *e*, *w*, *s*, or *c*, to the class numeral, for example, IIe. The letter *e* shows that the main limitation is risk of erosion unless close-growing plant cover is maintained; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage) ; *s* shows that the soil is limited mainly because it is shallow, droughty, saline, alkali, or stony; and *c*, used in only some parts of the United States, shows that the chief limitation is climate that is too cold or too dry.

In class I there are no subclasses, because the soils of this class have few limitations. Class V can contain, at the most, only the subclasses indicated by *w*, *s*, and *c*, because the soils in class V are subject to little or no erosion, though they have other limitations that restrict their use largely to pasture, range, woodland, wildlife, or recreation.

CAPABILITY UNITS are soil groups within the subclasses. The soils in one capability unit are enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity and other responses to management. Thus, the capability unit is a convenient grouping for making many statements about management of soils. Capability units are generally designated by adding an Arabic numeral to the subclass symbol, for example, IIe-1 or IIIe-20. Thus, in one symbol, the Roman numeral designates the capability class, or degree of limitation; the small letter indicates the subclass, or kind of limitation, as defined in the foregoing paragraph; and the Arabic numeral specifically identifies the capability unit within each subclass. In this survey Area, the irrigated capability units have a one-digit capability unit number (1), and the dryland capability units have a two-digit number (20).

The names of the soil series represented are mentioned in the description of each capability unit, but the listing of the series name does not necessarily indicate that all the soils of a series are in the same capability unit. The capability classification of any given soil can be learned by referring to the "Guide to Mapping Units."

In the following pages the capability units in the Benton County Area are described, and suggestions for the use and management of the soils are given.

Management by Irrigated Capability Units

Irrigation water is available in about 10 percent of the Benton County Area, predominantly areas irrigated by water diverted from the Yakima River. Where irrigation water is available, many kinds of irrigated crops are grown.

In this section the irrigated soils of the Benton County Area have been grouped by irrigated capability units.

IRRIGATED CAPABILITY UNIT I-1

This unit consists of well-drained, nearly level soils of the Esquatzel, Shano, and Warden series. These soils are generally more than 60 inches deep.

The water-holding capacity is high, and permeability is moderate. Surface runoff is very slow to slow. Water erosion is a slight hazard, and wind erosion is a slight to moderate hazard. The frost-free season is about 150 to 155 days.

Suitable crops are sugar beets, asparagus, potatoes, peas, mint, hops, grain, tree fruits, grapes, and hay and pasture.

Management needs include application of fertilizer in the amounts indicated by soil tests, use of suitable cropping systems, use of crop residue, and proper application of irrigation water. Irrigation water can be applied by corrugation, furrow, border, controlled flooding, or sprinkler systems. Deep cuts can be made in these soils with little or no effect on their suitability for crops.

IRRIGATED CAPABILITY UNIT IIe-1

This unit consists of Warden very fine sandy loam, 0 to 2 percent sloes, eroded. This soil is well drained. It is more than 60 Inches deep.

The water-holding capacity is high, and permeability is moderate. Surface runoff is very slow. Water erosion is only a slight hazard, but wind erosion is a moderate hazard when the surface is bare. The frost-free season is about 150 days.

Suitable crops are those that keep a permanent cover on the ground, such as tree fruits, grapes, and hay and pasture. Many other crops are also suitable.

Management needs include practices to control wind erosion, such as maintaining a vegetative cover as much of the time as possible, utilizing plant residue, and maintaining the organic-matter content. When the soil is bare, the surface should be left rough and cloddy to retard wind erosion. Fertilizer should be applied in the amounts indicated by soil tests. Irrigation water can be applied by corrugation, furrow, or sprinkler systems.

IRRIGATED CAPABILITY UNIT IIe-2

This unit consists of well-drained, medium-textured, gently sloping soils of the Burke, Esquatzel, Kennewick, Prosser, Scooteney, Shano, and Warden series. These soils are generally more than 60 inches deep, but shallow soils, no more than 20 inches deep, are included.

The water-holding capacity is moderate to high. Permeability is moderate to moderately slow. Surface runoff is slow. Erosion is a slight to moderate hazard. The frost-free season is about 150 to 160 days.

Suitable crops are sugar beets, mint, asparagus, potatoes, peas, corn, hops, grain, and hay. Tree fruits, grapes, and pasture are also suitable.

Management needs include application of fertilizer in the amounts indicated by soil tests, use of suitable cropping systems, use of crop residue, and proper application of irrigation water.

Either surface or sprinkler irrigation is suitable. Furrows and corrugations in surface systems should be held to a 2 percent gradient, or else runs should be short, to minimize the erosion hazard.

Calcareous soils and areas where a calcareous subsoil has been exposed in leveling are suited to grass and legume hay, pasture, or small grain the first few years under irrigation. Special emphasis should be placed on increasing the organic-matter content before growing row crops in areas of calcareous soils. If row crops are grown, phosphorus is needed, and in places, sulfur and zinc.

IRRIGATED CAPABILITY UNIT IIs-1

This unit consists of well-drained, medium-textured, nearly level soils of the Kennewick and Umapine series. These soils are more than 60 inches deep. They are strongly calcareous. They have either strongly alkaline or laminated layers that restrict plant roots until after the soil has been cropped several years.

The water-holding capacity is high. Permeability ranges from moderate to moderately slow. Surface runoff is very slow. Erosion is a slight hazard. The frost-free season is about 150 to 160 days.

For the first few years under irrigation, these soils are better suited to grass-and-legume hay and pasture than

to other crops. Sugar beets and asparagus are suitable after the fields have become uniformly productive.

Management needs include application of fertilizer, use of suitable cropping systems, with initial emphasis on adding organic matter to the soil, and proper application of irrigation water. Sulfur and a heavy application of phosphorus are needed by some crops.

Irrigation water can be applied by furrow, corrugation, border, controlled flooding, or sprinkler systems. Good drainage of subsoil water and tail water is important. For the first few years of irrigation, this drainage water is not suitable for reuse.

IRRIGATED CAPABILITY UNIT IIs-2

This unit consists of well-drained, medium-textured, nearly level soils of the Burke, Prosser, and Scooteney series. The Prosser and Burke soils are 20 to 36 inches deep over basalt bedrock or cemented hardpan, and the Scooteney soils are 10 to 24 inches deep over gravelly silt loam.

The water-holding capacity is moderate to moderately high, and permeability is moderate. Surface runoff is very slow. Water erosion is a slight hazard, and wind erosion is a slight to moderate hazard. The frost-free season is about 150 to 155 days.

Suitable crops are mint, corn, wheat, peas, hay, and pasture.

Management needs include application of fertilizer, especially nitrogen, in the amounts indicated by soil tests; use of suitable cropping systems; and use of crop residue.

Proper application of irrigation water is especially important where these soils occur in the same field with soils that have either high or low water-holding capacity. In such places one soil can be overirrigated, and an adjacent soil underirrigated. Water can be applied by furrow, corrugation, controlled flooding, or sprinkler systems.

IRRIGATED CAPABILITY UNIT IIIe-1

This unit consists of well-drained, medium-textured and moderately coarse textured soils of the Burke, Finley, Shano, and Warden series. The slope ranges from 2 to 8 percent. In most places the soils are more than 60 inches deep, but in some areas they are no more than 20 inches deep.

The water-holding capacity is moderate to high, and permeability is moderate to moderately rapid. Runoff is slow to medium. The hazard of water erosion is slight to moderate, and the hazard of wind erosion is severe when the surface is left without plant cover. The frost-free season is about 150 to 160 days.

The principal crops are tree fruits, grapes, hay, and pasture. Many other crops are suitable.

Management needs include practices to control wind erosion, such as utilizing crop residue, maintaining the organic-matter content, and keeping a vegetative cover on the soil as much of the time as possible. When the ground is bare, the surface should be left rough and cloddy. Minimum tillage is advisable. Irrigation water can be applied by sprinkler, corrugation, or furrow systems. Reducing the length of the furrows and corrugations helps to control water erosion.

IRRIGATED CAPABILITY UNIT IIIe-2

This unit consists of well-drained, medium-textured soils of the Burke, Kennewick, Scooteney, Shano, and Warden series. The slope ranges from 2 to 8 percent. The soils are 20 inches to more than 60 inches deep.

The water-holding capacity is moderate to high, and permeability is moderate to moderately slow. Surface runoff is slow to medium. The hazard of water erosion is slight to moderate. The frost-free season is about 150 to 160 days.

Suitable crops are tree fruits (fig. 2), grapes, hay, and pasture. Under good management, many other crops are suitable.

Figure 2.-A 6-year-old cherry orchard, where creeping red fescue has been used as a cover crop. The soil is Warden silt loam, 5 to 8 percent slopes. It is in irrigated capability unit IIIe-2.

Management needs include applying irrigation water in a way that will minimize the hazard of erosion. The soils are well suited to sprinkler irrigation. Furrows and corrugations in surface systems should be held to a 2 percent gradient, or else runs should be short, to minimize the erosion hazard. Careful investigation should precede leveling because the depth of the soils is variable. Fertilizer should be applied according to the needs of the crop to be grown. Management should also include use of crop residue, use of suitable cropping systems, and minimum tillage.

IRRIGATED CAPABILITY UNIT IIIw-1

This unit consists of somewhat poorly drained, dark-colored, medium-textured and moderately coarse textured, nearly level soils of the Pasco and Wamba series. In most places the soils are more than 60 inches deep, but in some areas of the Wamba soil, a substratum of basalt bedrock is at a depth of less than 60 inches.

The water-holding capacity is moderate to high, and permeability is moderately slow to moderate. In places the surface layer is strongly alkaline. In some places the water table is near the surface during part of the growing season. Surface runoff is very slow to ponded, and the hazard of water erosion is no more than slight. The hazard of wind erosion is moderate on Pasco fine sandy loam. The frost-free season is about 150 to 155 days.

Peas, corn, hay, and small grain are suitable crops in areas that are properly drained and irrigated. Water-

tolerant pasture plants, such as reed canarygrass, redtop, alta fescue, white clover, and strawberry clover, are suitable for undrained areas.

Drainage needs vary. Some areas need outlets; others need provision for intercepting water. Strongly alkaline areas can be made more suitable for crops by proper drainage and irrigation. In some of the low-lying areas along the river, the water table fluctuates with the rise and fall of the river. In these places a drainage system may be useful only in facilitating the rapid removal of water once the river has receded.

In undrained areas crops receive little or no benefit from fertilizer. In drained areas crops respond to fertilization, management of residue, and rotation of crops.

Irrigation water can be applied by furrow, corrugation, border, flooding, or sprinkler systems.

IRRIGATED CAPABILITY UNIT IIIs-1

This unit consists of well-drained, nearly level, moderately coarse textured and medium-textured soils of the Burke and Finley series.

The water-holding capacity is moderate to moderately high, and permeability is moderate to moderately rapid. Surface runoff is very slow. The hazard of wind erosion is moderate. The frost-free season is about 160 days.

Tree fruits, grapes, hay, and pasture are suitable crops. Management needs include minimum tillage, using extra care in leveling to avoid exposing the subsoil, maintaining the organic-matter content by management of crop residue, use of green-manure crops, and use of suitable cropping systems. Fertilizer, especially nitrogen, is needed.

Furrow, corrugation, border, and sprinkler irrigation systems are suitable. To minimize the erosion hazard, the length of furrows and corrugations should not exceed 440 feet.

IRRIGATED CAPABILITY UNIT IVe-1

This unit consists of well-drained, medium-textured and moderately coarse textured soils of the Burke, Finley, and Warden series. The slope ranges from 2 to 15 percent. In most places the soil is more than 30 inches deep, but in a few areas it is no more than 15 inches deep.

The water-holding capacity is low to high, and permeability is moderate to moderately rapid. Surface runoff is very slow to rapid. The hazard of water erosion is slight to severe; the hazard of wind erosion is moderate when the surface is bare. The frost-free season is about 150 to 160 days.

Hay, pasture, and orchard crops are suitable. In some places the Burke soil is too shallow for orchards and other deep-rooted crops.

Management needs include controlling erosion, maintaining the organic-matter content, using soil-building cropping systems, and maintaining as rough and cloddy a surface as possible.

These soils are well suited to sprinkler irrigation. Fertilizer should be applied according to the needs of the crop to be grown.

IRRIGATED CAPABILITY UNIT IVe-2

This unit consists of well-drained, medium-textured soils of the Burke, Kennewick, Prosser, Scooteney, Shano, Starbuck, and Warden series. The slope ranges from 5 to 15 percent. Although most of the soils are very deep, some are shallow.

The water-holding capacity ranges from low in the shallow soils to high in the deep soils. Permeability is moderate to moderately slow. Surface runoff is medium to rapid. The hazard of water erosion is moderate to high. The frost-free season is about 150 to 155 days.

These soils are well suited to permanent vegetation, such as hay and pasture. Orchards are well suite, except on the shallow soils, such as the Starbuck and Burke soils.

Management needs include controlling erosion, keeping a permanent cover on the soil as much of the time as possible, and using a minimum amount of tillage. The soils are better suited to sprinkler irrigation than to surface systems. All crop residue should be returned. Fertilizer should be applied according to the needs of the crop to be grown.

IRRIGATED CAPABILITY UNIT IVe-3

This unit consists of excessively drained and well-drained, coarse-textured soils of the Burbank, Hezel, and Quincy series. These soils are underlain by gravel, sand, or lacustrine material at a depth of 10 to 40 inches. The slope ranges from 0 to 15 percent.

The water-holding capacity is low to moderately high, and permeability is very rapid to moderate. Surface runoff is very slow to medium. The hazard of water erosion is slight to moderate, and the hazard of wind erosion is severe. The frost-free season is about 155 to 180 days.

These soils are suited to permanent crops, such as alfalfa, and to grass-and-legume pasture. Vineyards and orchards can be maintained under careful management.

Proper management of these soils is important. A sprinkler irrigation system is suitable, but adequate distribution of water is a problem. Light, frequent applications of water and split applications of fertilizer are effective. Furrow or subirrigation systems are used where the slope is 2 percent or less. Other practices needed include maintenance of a vegetative cover to minimize wind erosion, utilization of crop residue to maintain the organic-matter content, and care in leveling so as not to expose the gravelly, porous subsoil.

IRRIGATED CAPABILITY UNIT IVe-4

This unit consists of well-drained, shallow, medium-textured soils of the Burke and Starbuck series. The slope ranges from 0 to 8 percent.

The water-holding capacity is low, and permeability is moderate. Surface runoff is very slow to medium. The hazard of water erosion is slight to moderate, and the hazard of wind erosion is moderate. The frost-free season is about 150 to 155 days.

These soils are suited to hay and pasture, mint, small grain, and other shallow-rooted crops.

Sprinkler irrigation is suitable, but proper application of water is difficult because the soils are shallow. Light, frequent applications are effective. A few areas are suitable for corrugation or controlled flooding systems. Fertilizer should be applied according to the needs of the crop to be grown.

IRRIGATED CAPABILITY UNIT IVs-2

The only soil in this capability unit is Finley fine sandy loam, 0 to 2 percent slopes. This is a well-drained, moderately coarse textured soil underlain by very gravelly material at a depth of 10 to 30 inches.

The water-holding capacity is low, and permeability is moderately rapid. Surface runoff is very slow. The hazard of water erosion is slight, and the hazard of wind erosion is moderate when the surface is bare. The frost-free season is about 150 to 165 days.

This soil is suited to permanent vegetation, such as orchards, hay, and pasture.

Management needs include minimum tillage, leveling carefully to avoid exposing the gravelly subsoil, using all crop residue, and maintaining the organic-matter content. Fertilizer, especially nitrogen, is needed.

This soil is well suited to sprinkler irrigation. If a surface system is used, the length of corrugations should not exceed 440 feet, in order to keep the erosion hazard to a minimum.

Estimated yields of irrigated crops

Table 1 gives estimates of yields of the principal irrigated crops grown in the Area under good management. The figures are estimated averages for a period of years. In any given year, the yield may be substantially higher or lower than the average. Also, there is considerable variation of productivity in some soils because of variations in the height of the water table or in the content of salts and alkali.

It is advisable to consult local agricultural advisors from time to time for up-to-date information on improved crop varieties, on new methods of controlling insects and disease, and on improved methods of fertilization, tillage, irrigation, and drainage.

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All tables have been updated and are available as a separate document.

Following are examples of specific management practices, by crops, under which a farmer obtains the yields shown in table 1 from a representative irrigated soil.

For grapes (9) on Warden silt loam, 2 to 5 percent slopes-

Variety:	Concord.
Spacing:	8 x 9 feet-605 plants per acre.
Fertilization:	None.
Cover crop:	Vetch and barley.
Pruning:	December through February, leaving approximately 80 buds per plant; chop prunings and disk into soil.
Cultivation:	3 regular cultivations with grape hoe, timed to be most effective for weed control.
Irrigation:	
Method ----------	Furrow.
Frequency ----------	3 applications before harvest, beginning about June 1; 1 irrigation after harvest.
Amount ----------	28 to 36 inches.
Drainage ----------	Removal of tail water.
Insect control:	Dust with a suitable insecticide to control mealybugs, black vineweevils, and cutworms.
Harvest:	October 1.

For hops (3) (fig. 3) on Warden silt loam, 0 to 2 percent slopes-

Variety:	Cluster (early and late types), propagated from rhizome cuttings.
Spacing:	7 x 7 feet-889 plants per acre on 18-foot high trellis.
Fertilization:	150 pounds of nitrogen and 36 pounds of phosphorus per acre. Before establishing a new yard, 30 pounds of zinc sulfate per acre should be plowed down. Zinc spray should be used to correct zinc deficiency during the growing season.
Cover crop:	Vetch, seeded in July and disked in April.
Pruning:	Early spring pruning of excess shoots from the root stock; confine crowns to a reasonable area and remove all diseased parts.
Training:	When vines are about 2 feet long, one to three vines should be trained up each string and excess vines removed.
Cultivation:	Begin with disking in the cover crop and pruning. The condition of the soil and the weediness determine the advisability of later cultivations.
Irrigation	
Method ----------	Furrow.
Frequency----------	About 8 applications, beginning about April 1; 48-hour settings and 800-foot furrows.
Amount ----------	36 inches.
Drainage----------	Removal of tail water.

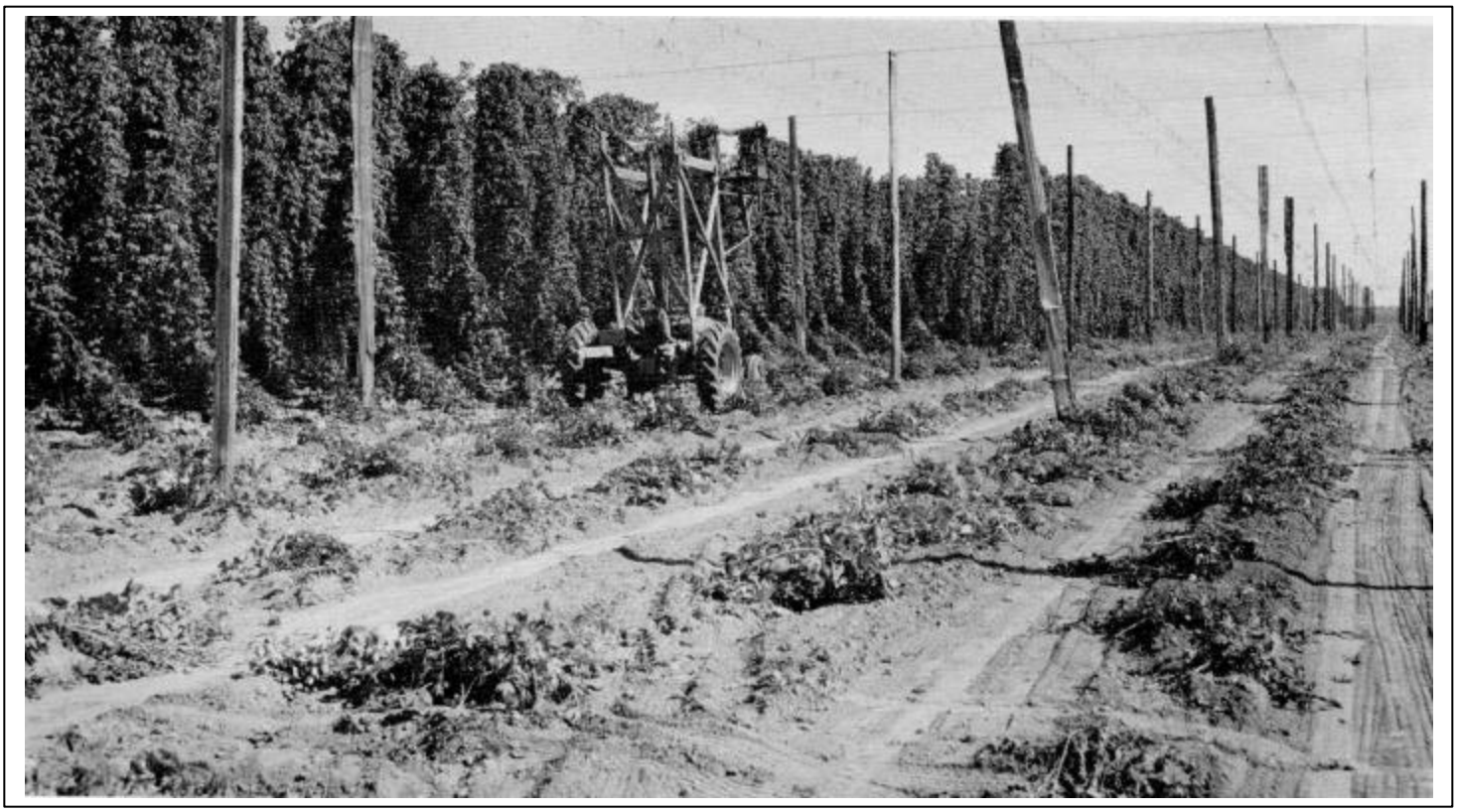

Figure 3.-Hops ready for harvest early in September. The soil is a Warden silt loam.

Insect and disease control: For downy mildew, apply fungicide, remove all affected shoots from the field and strip lower leaves at training time; use chemical spray or dust to control aphids and spider mites.

Harvest: Early Cluster, about August 20 ; Late Cluster, about September 10.

For mint (peppermint) on Warden silt loam, 0 to 2 percent slopes-

Rotation: Sugar beets 2 years, peppermint 3 years.

Preparation of seedbed : Plow, then disk to control weeds.

Fertilization: 160 pounds of nitrogen and 27 pounds of phosphorus per acre; broadcast fertilizer and disk in.

Planting: Stolons that are free of Verticillium wilt should be laid in the damp soil of newly turned furrows and immediately covered with 4 inches of soil.

Date ----------January to March.

Density ----------Solid in 32-inch row spacing.

Cultivation: Beginning March15-smooth and level with spike-tooth harrow once a week in alternating directions; beginning April 25 - ditch out and cultivate with springtooth harrow after each irrigation. Discontinue cultivation about June 15, when plants are large and are filling in.

Irrigation

Method ----------Furrow.

Frequency----------Begin about May 1, and irrigate every 14 days until hot weather sets in, then every 7 days until harvest; 24-hour setting.

Amount ----------48 inches.

Drainage ----------Removal of tail water.

Weed control: Mechanical: two hoeings about June 1 and July 1; turn geese into fields (about one goose per acre).

Insect control: Spray for two-spotted mites about June 1.

Harvest: September 1.

Additional: Return all mint hay to the field; spread out in winter.

For sugar beets (6) on Shano silt loam, 2 to 5 percent slopes-

Rotation: Alfalfa 3 years, corn 1 year, sugar beets 2 years.

Preparation of seedbed: Fall plow; spring till and pack. Prepare a level, fine granular, firm seedbed, but do not pack too firmly.

Fertilization: 180 pounds of nitrogen and 40 pounds of phosphorus per acre.

Seeding

Amount ----------6 pounds per acre of seed from which the husks have been removed; plant three-fourths of an inch deep in a firm, moist seedbed.

Date ----------About March 20.

Density ----------22-inch, row spacing.

Cultivation : First cultivation soon after plants have emerged and the rows are visible.

Thinning: Partial mechanical thinning, followed by hand thinning when plants have about 6 leaves (about May 15) ; leave one beet plant every 10 inches.

Weeding: Mechanical cultivation for weed control and furrowing out; hand hoeing when needed (2 or 3 times a year).

Irrigation

Method ----------Furrow.

Frequency ----------Irrigate every 8 days in alternate rows at peak of irrigation season; early irrigation is sometimes need to insure germination. Irrigate until harvest. (When the soil is at field capacity, replenish the amount of water used, but apply no more.)

Amount ----------36 inches.

Drainage ----------Removal of tail water.

Harvest: By machine in October.

For alfalfa (hay) on Warden silt loam, 2 to 5 percent slopes-

Rotation: Alfalfa 3 years, corn 1 year, sugar beets 2 years, green peas followed by summer seeding of alfalfa.

Preparation of seedbed : Plow, disk, and pack.

Fertilization: 44 pounds of phosphorus at seeding time.

Seeding: Use inoculated seed; sow no deeper than half an inch in firm, weed-free seedbed.

Variety----------Ranger or Vernal.

Rate---------- 10 pounds per acre.

Date---------- September 1.

Irrigation:

Method ---------- Corrugation, 32-inch width.

Frequency----------Irrigate first cutting twice, beginning about May 15 ; irrigate second and third cuttings 1 week before cutting; irrigate once after third cutting (a total of five applications).

Amount ---------- 36 inches.

Drainage ---------- Removal of tail water.

Harvest: Cut in late bud stage, 3 or 4 cuttings a year.

For pasture (5) on Shano silt loam, 2 to 5 percent slopes-

Rotation: Pasture 5 years, sugar beets 2 years, and green peas 1 year, followed by reestablishment of pasture.

Preparation of seedbed: Plow, disk, and pack.

Fertilization: 125 pounds of nitrogen and 22 pounds of phosphorus per acre at planting; annual application of 100 pounds of nitrogen in three equal applications, one about the last of March, one in the middle of June, and one early in August; 22 pounds of phosphorus per acre, broadcast each fall.

Seeding: Use inoculated legume seeds; sow no deeper than 1/2 inch in firm, weed-free seedbed.

Variety---------- S-143 orchardgrass and Ranger alfalfa.

Rate----------10 pounds of orchardgrass and 5 pounds of alfalfa per acre.

Date----------Seed no later than September 15.

Irrigation

Method ----------Rill; corrugations spaced 36 inches apart.

Frequency----------Every 10 days during period of maximum consumption.

Amount ----------36 inches per season.

Drainage ----------Removal of tail water.

Grazing: .

Schedule----------Rotation pasture is based on stage of growth; allow alfalfa and grass to reach a minimum growth of 12 to 14 inches, then graze back to about 2 to 4 inches; pasture season normally extends from about May 1 to early in October.

Other practices---_ Clipping excess growth, spreading dung, ditching, fertilizing, and irrigating should be scheduled so as to not interfere with grazing.

Management by Dryland Capability Units

In those areas where natural precipitation is adequate, suitable soils are used for dryland farming. The main dryland crop is winter wheat.

In this section the dryland soils of the Benton County Area have been grouped by dryland capability units.

DRYLAND CAPABILITY UNIT IIc-20

This unit consists of Walla Walla silt loam, 0 to 5 percent slopes, a well-drained, medium-textured soil. This soil is more than 60 inches deep in most places, but in some it is between 36 and 60 inches in depth. It occurs on high terraces in the Rattlesnake Hills. Elevations range from about 2,200 to 3,300 feet. The annual precipitation amounts to 11 to 15 inches, and the frost-free season is about 130 days.

The water-holding capacity is high, and permeability is moderate. Surface runoff is very slow to slow. The hazard of water and wind erosion is slight.

This soil is used mainly for wheat. It is one of the most consistently productive of the dryland soils.

In some years a sharp rise in temperature brings abrupt snowmelt while the ground is still frozen. The rapid runoff that results not only carries off the water that would otherwise recharge the ground supply, but also carries off some of the soil.

Management practices should include stubble-mulch tillage, diversion of runoff water, and seeding along the contour. The soil should be cultivated only enough to control weeds and to prepare the seedbed. Fall chiseling of stubble checks runoff over frozen ground. Crops generally respond to nitrogen.

DRYLAND CAPABILITY UNIT IIIe-20

This unit consists of well-drained, medium-textured soils of the Endicott and Walla Walla series. These soils occur on high terraces in the Rattlesnake Hills. They are 20 to more than 60 inches deep. The slope ranges from 5 to 15 percent. Elevations range from 2,200 to 3,500 feet. The annual precipitation amounts to 11 to 15 inches, and the frost-free season is about 130 days.

The water-holding capacity is moderate to high, and permeability is moderate. Surface runoff is slow to medium. Water erosion is a slight to moderate hazard, and wind erosion is a slight hazard.

These soils are used mainly for production of wheat. Management practices should include stubble-mulch tillage, cross-slope tillage, diversion of runoff water, and cultivation only to control weeds and to prepare the seedbed. Fall chiseling of stubble checks runoff over frozen ground. Crops generally respond to nitrogen.

DRYLAND CAPABILITY UNIT IIIe-21

This unit consists of Esquatzel fine sandy loam, 0 to 5 percent slopes, a well-drained, very deep soil on bottom lands. Elevations range from 300 to 1,400 feet. The annual precipitation amounts to 6 to 12 inches, and the frost-free season is about 150 days.

The water-holding capacity is high, and permeability is moderate. Runoff is very slow to slow. Water erosion is a slight hazard, and wind erosion is a moderate hazard.

In cultivated areas, timely practices that minimize the hazard of wind erosion and properly utilize the limited moisture supply are important. Management practices should include minimum tillage, diversion of runoff, deep-furrow seeding at right angles to prevailing winds, Art cropping, and stubble-mulch tillage. This soil should be cultivated only to control weeds and to prepare the seedbed.

DRYLAND CAPABILITY UNIT IIIs-20

This unit consists of well-drained, medium-textured soils of the Endicott and Willis series. These soils are 20 to 36 inches deep. The slope ranges from 0 to 5 percent. Elevations range from 1,200 to 3,000 feet. The annual precipitation amounts to 9 to 15 inches, and the frost-free season is about 130 to 140 days.

The water-holding capacity is moderate to moderately high, and permeability is moderate. Surface runoff is very slow to slow. Water erosion is a slight to moderate hazard, and wind erosion is a slight to moderate hazard. In years when moisture is plentiful, the soils become saturated and erosion is a serious hazard.

These soils are used mainly for wheat. If rainfall is especially low in May and June, the crop may be seriously retarded. Management practices should include stubble-mulch tillage, cross-slope tillage, deep-furrow seeding, minimum tillage, and diversion of runoff. The soils should be cultivated only to control weeds and to prepare the seedbed.

DRYLAND CAPABILITY UNIT IIIs-20

This unit consists of well-drained, medium-textured soils of the Ellisforde, Esquatzel, and Ritzville series. These soils occur in Horse Heaven Hills and in the Rattlesnake Hills. They are generally more than 60 inches deep but in some areas are between 36 and 60 inches in depth. The slope ranges from 0 to 5 percent. Elevations range from 1,000 to 2,500 feet. The annual precipitation amounts to 9 to 12 inches, and the frost-free season is about 140 to 150 days.

The water-holding capacity is high, and permeability is moderate to moderately slow. Surface runoff is slow to very slow. Water erosion is a slight hazard, and wind erosion is a slight to moderate hazard (fig. 4).

These soils are used mainly for production of wheat**.** Management practices should include stubble-mulch tillage, deep-furrow seeding at right angles to prevailing winds, diversion of runoff, and minimum tillage. The soils should be cultivated only to control weeds and to prepare the seedbed. Crops generally respond to nitrogen.

DRYLAND CAPABILITY UNIT IVe-20

This unit consists of well-drained, medium-textured soils of the Ellisforde, Ritzville, and Walla Walla series. These soils generally occupy breaks extending from high terraces of the Rattlesnake Hills and Horse Heaven Hills. They are generally more than 36 inches deep. The slope ranges from 15 to 30 percent. In places all the surface soil has been removed by erosion, and shallow gullies

Figure 4.-Windblown sand that has nearly covered a fence. Grasses have been used to stabilize the bank. The crop shown in the right foreground is winter wheat. Sands were derived from Ritzville silt loam.

leading to deep gullies or intermittent streams are common. Elevations range from about 1,000 to 3,000 feet. The annual precipitation amounts to 9 to 15 inches, and the frost-free season is about 130 to 150 days.

The water-holding capacity is high, and permeability is moderate. Surface runoff is medium to rapid. Water erosion is a moderate to severe hazard.

Most of the acreage is used for grazing. In some places wheat, rye, or barley is grown in a summer-fallow system. Management practices should include cross-slope tillage, stubble-mulch tillage, minimum tillage, and cross-slope seeding.

DRYLAND CAPABILITY UNIT IVe-21

This unit consists of well-drained, medium-textured soils of the Ritzville, Shano, and Warden series. These soils occupy terraces at elevations ranging from about 500 to 2,000 feet. They are generally more than 60 inches deep but in some areas are between 36 and 60 inches in depth. The slope ranges from 0 to 15 percent. The annual precipitation amounts to 6 to 12 inches, and the frost-free season is about 140 to 150 days.

The water-holding capacity is high, and permeability is moderate. Runoff is slow to very slow. Water erosion is a slight hazard, and wind erosion is a moderate hazard.

About half the acreage is used for range, and half for wheat. In cultivated areas, timely practices that control wind erosion and properly utilize the limited moisture supply are important. Management practices should include minimum tillage, diversion of runoff, deep-furrow seeding at right angles to prevailing winds, stripcropping, and stubble-mulch tillage. The soils should be cultivated only to control weeds and to prepare the seedbed.

DRYLAND CAPABILITY UNIT IVe-22

This unit consists of well-drained, moderately deep, medium-textured soils of the Burke, Scooteney, and Prosser series. These soils are underlain by a cemented hardpan, very gravelly loam, or basalt bedrock. They occupy terraces at elevations ranging from about 400 to 1,300 feet. In most places the slope is between 0 and 5 percent, but it ranges from 0 to 30 percent. The annual precipitation amounts to 6 to 9 inches, and the frost-free season is about 150 to 155 days.

The water-holding capacity is moderate to moderately high, and permeability is moderate. Surface runoff is very slow to slow. The hazard of both water and wind erosion is slight to moderate.

Most of the acreage is used for grazing, but in places wheat, rye, or barley is grown in a summer-fallow system. Management practices should include stubble-much tillage, deep-furrow seeding at right angles to prevailing winds, and minimum tillage. The soils should be cultivated only to control weeds and to prepare the seedbed. Crops generally .respond to nitrogen.

DRYLAND CAPABILITY UNIT IVc-20

This unit consists of well-drained, medium-textured soils of the Shano and Warden series. These soils occupy terraces at elevations ranging from about 500 to 1,300 feet. The slope ranges from 0 to 5 percent. The soils are generally More than 60 inches deep. The annual precipi-

tation amounts to 6 to 9 inches, and the frost-free season is about 150 days.

The water-holding capacity is high, and permeability is moderate. Surface runoff is very slow to slow. Water erosion is a slight hazard, and wind erosion is a slight to moderate hazard.

These soils are used for wheat, rye, barley, or range. Management practices should include stubble-mulch tillage, and deep-furrow seeding at right angles to prevailing winds. The soils should be cultivated only to control weeds and to prepare the seedbed. Crops generally respond to nitrogen.

DRYLAND CAPABILITY UNIT VIe-20

This unit consists of well-drained, medium-textured soils of the Burke, Endicott, Kennewick, Shano, Warden, and Willis series. These soils are shallow, severely eroded, or highly susceptible to erosion. In most places the slope is between 15 and 30 percent, but it ranges from 0 to 40 percent. The annual precipitation amounts to 6 to 15 inches, and the frost-free season is 130 to 155 days.

The water-holding capacity is low to high, and permeability is moderate. Runoff is very slow to rapid.

These soils are suitable for grazing. Seeding for range improvement is practical.

DRYLAND CAPABILITY UNIT VIe-21

This unit consists of well-drained, medium-textured soils of the Ritzville and Walla Walla series. These soils are moderately deep to deep. The slope ranges from 30 to 65 percent. The annual precipitation amounts to 6 to 15 inches, and the frost-free season is 130 to 150 days.

The water-holding capacity is high, and permeability is moderate. Runoff is rapid to very rapid. The hazard of water erosion is severe to very severe.

These soils are suitable for grazing. Seeding for range management is practical.

DRYLAND CAPABILITY UNIT VIe-22

This unit consists of well-drained, medium-textured and moderately coarse textured soils of the Burke, Finley, and Prosser series. These soils are 20 to 36 inches deep. The slope ranges from 0 to 15 percent. The annual precipitation amounts to 6 to 9 inches, and .the frost-free season is about 150 to 155 days.

The water-holding capacity is low to moderately high, and permeability is moderate. Runoff is very slow to slow. The hazard of erosion is slight to moderate.

These soils are suitable for grazing. Seeding for range improvement is practical.

DRYLAND CAPABILITY UNIT VIs-22

This unit consists of Umapine silt loam, 0 to 5 percent slopes, a deep, moderately well drained, saline-alkali soil. The annual precipitation amounts to 6 to 9 inches, and the frost-free season is about 150 days.

Runoff is very slow, and the hazard of erosion is slight.

This soil is suitable for grazing. Seeding for range improvement is practical.

DRYLAND CAPABILITY UNIT VIIe-21

This unit consists of well-drained, medium-textured soils of the Burke, Shano, Warden, and Willis series. The slope ranges from 30 to 65 percent. The annual precipitation amounts to 6 to 9 inches, and the frost-free season is about 150 to 155 days.

The water-holding capacity is moderate to high, and permeability is moderate. Runoff is rapid to very rapid. The hazard of water erosion is severe to very severe.

These soils are used to a limited extent for grazing. Mechanical range improvement practices are not practical. Proper grazing use and grazing systems that provide periodic rest from grazing in order to improve plant vigor are appropriate.

DRYLAND CAPABILITY UNIT VIIe-23

This unit consists of excessively drained to well-drained, coarse-textured soils of the Burbank, Hezel, Koehler, and Quincy series. These soils are moderately deep to deep. The slope ranges from 0 to 30 percent. The annual precipitation amounts to 6 to 9 inches, and the frost-free season is about 155 to 180 days.

The water-holding capacity is low to moderately high, and permeability is rapid to very rapid. Runoff is very slow to slow. The hazard of wind erosion is severe.

These soils are used to a limited extent for grazing. Maintaining ground cover and controlling soil drifting are serious problems. Preparation of a seedbed for grasses is not practical.

DRYLAND CAPABILITY UNIT VIIs-20

This unit consists of excessively drained to well-drained, coarse-textured to medium-textured soils of the Burbank, Burke, Finley, Mona, Lickskillet, Scooteney, and Starbuck series. The soils are rocky or very stony. The slope ranges from 0 to 65 percent. The annual precipitation amounts to 6 to 15 inches, and the frost-free season is 130 to 180 days.

The water-holding capacity is low to moderate, and permeability is very rapid to moderately slow. Runoff ranges from very slow to very rapid. The hazard of erosion ranges from slight to very severe.

These soils are used to a limited extent for grazing and for wildlife habitat. Preparation of a seedbed for grasses is not practical.

DRYLAND CAPABILITY UNIT VIIIe-20

This unit is made up of Dune land, a land type that consists of deep, loose, wind-worked fine sand. The dunes are active and vary in size and shape, but they are predominantly 5 to 20 feet high. They are barren and have no agricultural value.

DRYLAND CAPABILITY UNIT VIIIw-20

This unit is made up of Riverwash, a land type that consists mainly of sand and gravel bars along rivers and streams. These areas are subject to flooding and shifting when the streams overflow. Most areas are bare of vegetation. They have no agricultural value.

DRYLAND CAPABILITY UNIT VIIIs-20

This unit is made up of Rock outcrop, a land type that consists of vertical escarpments and outcrops of basalt. The slope ranges from gently sloping to very steep. This land type has no agricultural value.

Estimated yields of dryland wheat

Table 2 lists the soils in this Area that are used mainly for winter wheat and gives estimates of average yields over a 5-year period using a summer-fallow system, where a crop is grown every other year. The estimates are given only for high-level management, because such management is necessary to prevent crop failure. They are based on the experience of individual farmers and on data provided by Federal agricultural advisors.

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All tables have been updated and are available as a separate document.

Basically the same cultural practices are followed throughout the Area, but the intensity and timing of operations vary from one place to another, largely because of variations in the weather. The following are typical practices in a harvest-to-harvest cycle on Warden silt loam, 0 to 5 percent slopes

July 5----------Harvest; after harvest, nothing is done until the following spring.

March 1---------Stubble-mulch; a disk plow is used if the stubble is thick, or a chisel-sweep plow if the stubble is light.

April l----------Cultivation and seal-off with rod weeder.

June 15---------Cultivation with rod weeder, if needed. In years when rainfall is low, this cultivation may not be necessary.

August 1--------Spot weeding with small tractor, or hand weeding.

October 1------ Cultivation with rod weeder if rainfall has amounted to more than half an inch since last weeding, followed immediately (no later than October 15) by seeding. Seeding rate should be 55 to 70 pounds per acre. Seed in dust, deep furrows (3 to 4 inches deep) with 14-inch spacing, 1/2 inch to 1 inch of soil should cover seed.

Additional practices should include spraying with chemicals, if needed, for control of tarweed, Russian-thistle, and mustard, as well as fertilizing with 20 to 30 pounds of nitrogen per acre if there is adequate moisture.

Range

Nearly half, or approximately 397,530 acres, of the Benton County Area is used for range. This acreage consists mainly of areas on sandy terraces along the Yakima and Columbia Rivers and on the upper slopes and steep breaks of the Rattlesnake Hills and Horse Heaven Hills. The areas are generally unsuitable for cultivation.

The livestock industry is the third largest agricultural enterprise in the Area. The income from livestock is derived mainly from production of stocker and feeder cattle, of lambs, and of wool.

Most of the ranchers in the Area depend on native forage for livestock feed the year around. Hay is fed as partial or full feed only during calving or lambing time and when bad weather prevents grazing, usually about 1 or 2 months out of the year. Some of the ranchers use a protein supplement during periods late in summer and early in fall when the feed is dry.

Range sites and condition classes

Proper range management requires knowledge of the capabilities of the soils that make up a range site and the kinds and amounts of forage that can be produced. A rancher also needs the ability to evaluate the present condition of the vegetation in relation to its potential.

For the purpose of classifying range resources, soils are placed, in groups called range sites. Each site has a distinctive potential plant community, the composition of which depends upon a combination of environmental conditions, mainly the combined effects of soil and climate. The potential plant community reproduces itself so long as the environmental conditions remain the same. Generally, the potential plant community is the most productive combination of forage plants that will grow on a range site.

Following is a list of the common and scientific names of the range plants that generally make up the vegetation on the range sites of this Area.

By HARRY H. WEGELEBEN, range conservationist, Soil Conservation Service, Yakima, assisted by JACK J. RASMUSSEN, soil scientist, Soil Conservation Service.

Common name	Scientific name
Alkali bluegrass	*Poa juncifolia*
Alkali cordgrass	*Spartina gracilis*
Antelope bitterbrush	*Purshia tridentata*
Basin wildrye	*Elymus cinerens*
Bluebunch wheatgrass	*Agropyron spicatum*
Big bluegrass	*Poa ampla*
Big sagebrush	*Artemisia tridentata*
Black greasewood	*Sarcobatus veriniculatus*
Bottlebrush squirreltail	*Sitanion hystrix*
Buckwheat, wild	*Eriogonum spp.*
Cheatgrass brome	*Bromus tectorum*
Cocklebur	*Xanthium spp.*
Currant	*Ribes spp.*
Cusick bluegrass	*Poa Cusicki*
Groundsmoke	*Gayophytuin spp.*
Horsebrush	*Tetradymia canescens*
Idaho fescue	*Festuca idahoensis*
Indian ricegrass	*Oryzopsis hymenoides*
Inland saltgrass	*Distichlis stricta*
Needle-and-thread	*Stipa comata*
Pacific fescue	*Festuca pacifica*
Plantain	*Plantago*
Prairie junegrass	*Koeleria cristata*
Prickly lettuce	*Lactuca serriola*
Rabbitbrush	*Chrysothamnus spp.*
Ragweed, common	*Ambrosia artemisifolia*
Rose	*Rosa spp.*
Sandberg bluegrass	*Poa secunda*
Sandbur	*Cenchrus pauciforacs*
Sixweeks fescue	*Festuca octoflora*
Serviceberry	*Amelanchier spp.*
Spiny hopsage	*Grayia spinosa*
Tarweed	*Madia spp.*
Thickspike wheatgrass	*Agropyron dasystachyum*
Threadleaf sedge	*Carex filifolia*
Threetip sagebrush	*Artemisia tripartita*
Thurber needlegrass	*Stipa thurberiana*
Willowweed	*Epilobium spp.*
Yellow wildrye	*Elymus flavescens*

Livestock are selective in their grazing habits. They seek out the more palatable and nutritious plants. The most heavily grazed plants are referred to as decreasers because they are the first to be depleted by close grazing (4). The less palatable plants are referred to as increasers because they withstand intensive grazing and replace the more desirable plants. Weeds and other plants that invade the site after the desirable plants have been reduced are referred to as invaders.

The relationship between the present vegetation and the potential plant community is measured in terms of range condition. Range condition is evaluated to determine the degree of deterioration that has taken place in the original plant cover, as well as to provide a basis for predicting the amount of improvement possible. It is expressed in terms of condition classes. Four classes are used to indicate the degree to which the potential plant community has been changed by grazing or other use.

The range is in excellent condition (fig. 5) if 76 to 100 percent of the stand consists of the original plant cover. It is in good condition if the percentage is between 51 and 75 ; in fair condition if the percentage is between 26 and 50; and in poor condition if it is 25 or less.

Production of forage

The main factors that influence the production of forage on a given range site in any single year are the condition of the range and the amount of precipitation that year. A site generally produces more forage when it is in excellent condition than when it is in good, fair, or poor condition. Variation in precipitation from year to

Figure 5.-Areas of range in contrasting condition. The range on the near side of the fence is in excellent condition; that on the far side is in poor condition. The soil is a Warden silt loam.

year cause marked variation in forage yield. Stocking rates must, therefore, be adjusted on a given range site to reflect differences in range condition and even from year to year on the same range site in one condition class, depending on the precipitation.

In table 3 are estimates of forage production expressed in animal unit months for each of the eight range sites in the Benton County Area. These estimates are based on local grazing history and on field observations. The stocking rate for a particular grazing unit must be evaluated according to its own particular conditions in accord with intended use and management.

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All tables have been updated and are available as a separate document.

Descriptions of range sites

The range sites of the Benton County Area are described in the following pages. The soil series represented are named in the description of each site, but this does not mean that all the soils of a given series are in the site. The description of each range site gives significant soil characteristics, lists the principal range plants, and gives estimates of total annual yields.

Table 4 lists representative species in the potential plant community and gives the range in percentage of such plants in the total annual yield.

To learn the range site for any given soil in the Area, refer to the "Guide to Mapping Units." The soils used primarily for irrigated crops are not assigned to range sites. Also, the following land types are unsuitable for use as range and are not included in any range site: Dune land, Riverwash, and Rock outcrop.

ALKALI RANGE SITE

Umapine silt loam, 0 to 5 percent slopes, is the only soil in this range site. This is a moderately well drained, saline-alkali soil. The site occupies only about 700 acres, and of this, nearly 200 acres is used for irrigated hay and pasture. Most of the acreage still in native vegetation occurs along the Columbia River in an area that will be under water upon completion of a dam now under construction.

The vegetation consists of basin wildrye, alkali bluegrass, inland saltgrass, alkali cordgrass, and scattered clumps of black greasewood. Reseeding is]practical. Saltgrass and greasewood are dominant in unirrigated areas that have been overgrazed.

If the site is in excellent condition, the total annual yield ranges from 4,000 pounds per acre in favorable years to 2,000 pounds per acre in unfavorable years.

BOTTOMLAND RANGE SITE

This range site occurs mainly as fingerlike strips along narrow canyon bottoms. The soils are members of the Esquatzel series. These are deep, well-drained fine sandy loams and silt loams. More than half the acreage is irrigated.

All the areas are suitable for range seeding. Stands of suitable perennial grasses can be established if a firm, weedfree seedbed is prepared.

If the site is in excellent condition, bluebunch wheatgrass and basin wildrye are dominant. Idaho fescue, Sandberg bluegrass, Thurber needlegrass, needle-and-thread, and threadleaf sedge make up as much as 15 percent of the vegetation.

If the site is overgrazed, the dominant plants are largely replaced by cheatgrass brome, six-weeks fescue, big sagebrush, rabbitbrush, and annual weeds.

If the range is in excellent condition, the total annual yield ranges from 6,000 pounds per acre in favorable years to 4,000 pounds per acre in unfavorable years.

LOAMY RANGE SITE
(6 TO 9 INCHES PRECIPITATION)

This range site occurs at slightly higher elevations than the Sandy and Sandy Loam range sites, but it is closely associated with those sites and in many places the areas overlap. The soils are members of the Burke, Kennewick, Prosser, Scooteney,. Shano, and Warden series. These are

generally dark grayish-brown very fine sandy loams and silt loams more than 30 inches deep. They are well drained and moderately permeable. Wind erosion is a moderate to severe hazard. Elevations range from 600 to 1,800 feet.

Because of its extensive acreage, this is one of the most important range sites in the Benton County Area. It is suitable for grazing in spring, late in fall, and in winter. Suitability for summer grazing can be improved by the use of protein supplement during periods when the feed is dry and by the use of plastic pipelines to improve watering places (fig. 6). Range seeding is effective except on Scooteney stony silt loam and on areas of other soils where the slope is more than 40 percent.

If the site is in excellent condition, beardless bluebunch wheatgrass is dominant. Thurber needlegrass, Sandberg bluegrass, Cusick bluegrass, Idaho fescue, Indian ricegrass, and needle-and-thread are other range plants. Big sagebrush and rabbitbrush are the dominant shrubs.

If the site is overgrazed, the dominant range plants are Sandberg bluegrass, needle-and-thread, cheatgrass brome and other annuals, six-weeks fescue, groundsmoke, annual plantain, willowweed, and big sagebrush.

If the range is in excellent condition, the total annual yield ranges from 1,000 pounds per acre in favorable years to 400 pounds per acre in unfavorable years.

LOAMY RANGE SITE (9 TO 15 INCHES PRECIPITATION)

This range site (fig. 7) occurs on foot slopes, terraces, and uplands, mainly on south-facing slopes. The soils are members of the Ellisforde, Endicott, Ritzville, Walla Walla, and Willis series. These are mainly dark grayish-brown to dark-brown silt loams more than 30 inches deep. They are nearly level to steep. Elevations range from 750 to 3,000 feet.

This site is suitable for grazing late in spring, early in summer, and late in fall. The vegetation consists of bluebunch wheatgrass, Idaho fescue, Sandberg bluegrass, Cusick bluegrass, Thurber needlegrass, big bluegrass, basin wildrye, prairie junegrass, Indian ricegrass, and needle-and-thread. The plant cover is thicker and more productive than that of the Loamy range site where precipitation is 6 to 9 inches.

If the site is in excellent condition, bluebunch wheatgrass is dominant. Antelope bitterbrush, big sagebrush, rabbitbrush, and horsebrush make up 3 percent of the vegetation.

If the site is overgrazed, the dominant vegetation is Sandberg bluegrass, needle-and-thread, cheatgrass brome, six-weeks fescue, groundsmoke, annual plantain, willowweed, and big sagebrush. Overgrazing increases the hazard of water erosion.

If the range is in excellent condition, the total annual yield ranges from 1,400 pounds per acre in favorable years to 700 pounds in unfavorable years.

SANDY RANGE SITE

This range site occurs on broad, undulating terraces and hills along the Columbia River and the lower part of the Yakima River. The soils are members of the Burbank, Hezel, Koehler, and Quincy series. These are light-colored loamy fine sands and loamy sands underlain by gravel, a cemented hardpan, reworked lake sediments, or basalt bedrock. They are low in organic-matter content. Wind erosion is a severe hazard. The slope ranges from 0 to 65 percent. Elevations range from 250 to 1,300 feet.

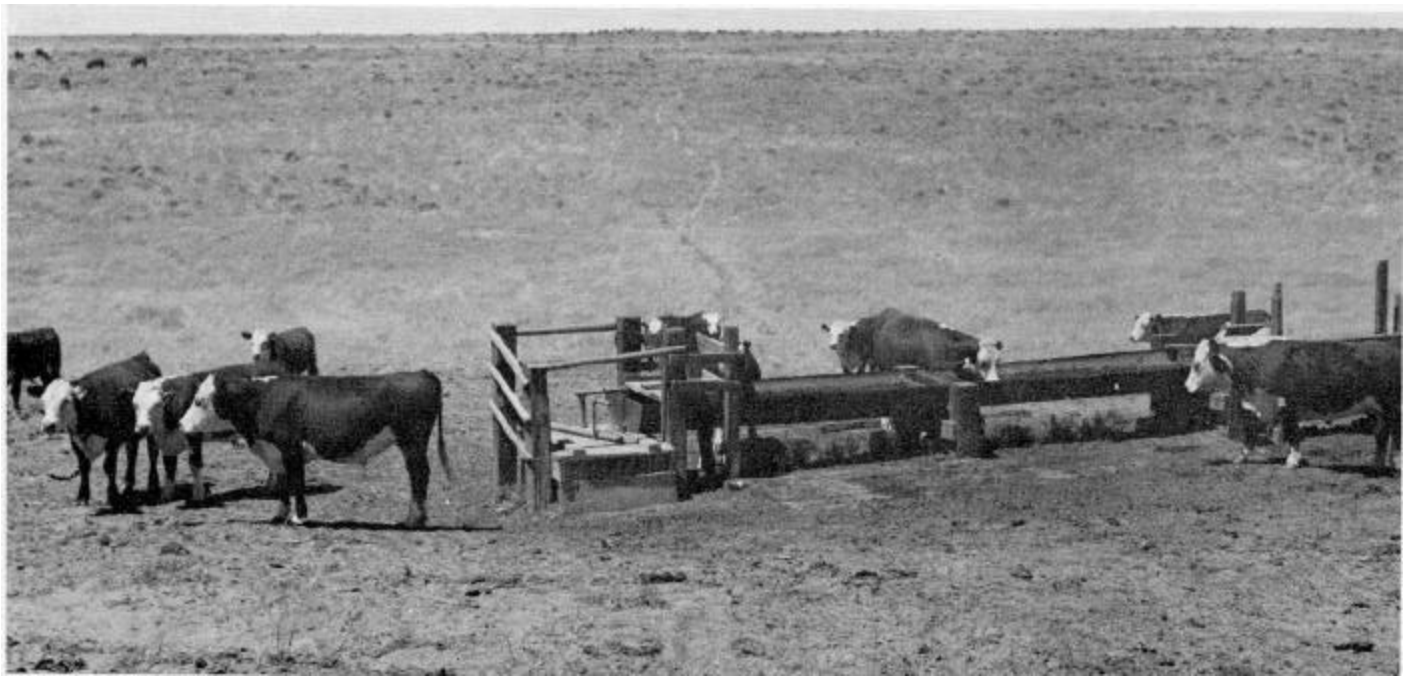

Figure 6.-Cattle at watering trough placed in an area of the Loamy range site. Water stored in facilities such as this contributes greatly to proper use of range resources. This soil is a Warden silt loam.

Figure 7.-Area of the Loamy range site. Bluebunch wheatgrass makes up 40 to 90 percent of the vegetation when this site is in excellent condition. The soil is a Ritzville silt loam.

Although commonly grazed the year around, this site is better suited to grazing late in fall, in winter, and early in spring. Grazing must be carefully controlled in summer to minimize trampling, which damages these sandy soils when the weather is hot and dry. Even under good grazing management, blowouts frequently develop during high winds.

If the site is in excellent condition, needle-and-thread is dominant. Other range plants are bluebunch wheatgrass, Indian ricegrass, prairie junegrass, Sandberg bluegrass, thickspike wheatgrass, yellow wildrye, and bottlebrush squirreltail. Antelope bitterbrush, rabbitbrush, spiny hopsage, and wild buckwheat make up as much as 15 percent of the plant cover.

If the site is overgrazed, the perennial grasses are largely replaced by such annuals as cheatgrass brome, Pacific fescue, cocklebur, prickly lettuce, annual plantain, sandbur, ragweed, tarweed, and other undesirable plants.

If the range is in excellent condition, the total annual yield ranges from 700 pounds per acre in favorable years to 300 pounds per acre in unfavorable years.

SANDY LOAM RANGE SITE

This range site occurs in close association with the Sandy range site. The soils are like those of that range site, except that their surface texture is fine sandy loam or stony fine sandy loam. They are members of the Finley series.

If the site is in excellent condition, bluebunch wheatgrass and needle-and-thread are dominant. These grasses make up 80 to 90 percent of the vegetation. Thurber needlegrass, Sandberg bluegrass, Indian ricegrass, prairie junegrass, thickspike wheatgrass, and Idaho fescue are other range plants. Antelope bitterbrush, big sagebrush, rabbitbrush, horsebrush, and currant bushes make up as much as 5 percent of the vegetation.

If the site is overgrazed, the perennial grasses are largely replaced by such annuals as cheatgrass brome, Pacific fescue, cocklebur, prickly lettuce, annual plantain, sandbur, ragweed, tarweed, and other undesirable plants. The nonstony soil can be reseeded.

If the range is in excellent condition, the total annual yield ranges from 1,000 pounds per acre in favorable years to 400 pounds per acre in unfavorable years.

SHALLOW RANGE SITE (6 TO 9 INCHES PRECIPITATION)

This range site consists mainly of gently sloping to rolling soils of the Burke and Starbuck series. These soils have a surface layer of silt loam. They are less than 20 inches deep over a lime-silica hardpan or basalt bedrock. The slope ranges from 0 to 45 percent. Elevations range from 500 to 1,800 feet.

These soils support the same kind of vegetation as the Loamy range site in this precipitation zone, but their shallowness limits the water-holding capacity sufficiently to cause a significant difference in stocking rates.

If the site is in excellent condition, bluebunch wheatgrass is dominant. Thurber needlegrass, Sandberg bluegrass, Cusick bluegrass, Indian ricegrass, and needle-and-thread are other range plants. Big sagebrush and rabbitbrush are the dominant rubs.

If the site is overgrazed, the dominant range plants are Sandberg bluegrass, needle-and-thread, cheatgrass brome and other annuals, six-weeks fescue, groundsmoke, annual plantain, willowweed, and big sagebrush.

If the range is in excellent condition, the total annual yield ranges from 450 pounds per acre in favorable years to 200 pounds per acre in unfavorable years.

SHALLOW RANGE SITE (9 TO 15 INCHES PRECIPITATION)

This range site occurs on foot slopes, canyon breaks, and uplands. In many places it is geographically associated with the Loamy range site. The soils are members of the Endicott, Kiona, Lickskillet, and Willis series. These are generally very dark grayish-brown to very dark brown silt loams 14 to 36 inches deep. They are moderately sloping to steep. Some are very stony.

Although this site is less productive than the Loamy range site, management needs are much the same. The site is suitable for grazing late in spring, early in summer, and late in fall. Range seeding is effective on the Endicott silt loams and on areas of Willis silt loams where the slope is less than 40 percent. The vegetation consists of bluebunch wheatgrass, Idaho fescue, Sandberg bluegrass, Thurber needlegrass, needle-and-thread, threadleaf sedge, and prairie junegrass.

If the site is in excellent condition, bluebunch wheatgrass is dominant. Big sagebrush and wild buckwheat make up as much as 3 percent of the vegetation. Rabbitbrush and horsebrush are scattered here and there.

If the site is overgrazed, Sandberg bluegrass, Thurber needlegrass, needle-and-thread, and threadleaf sedge increase in abundance.

If the range is in excellent condition, the total annual yield ranges from 700 pounds per acre in favorable years to 400 pounds per acre in unfavorable years.

Engineering Uses of the Soils

Some soil properties are of special interest to engineers because they affect the construction and maintenance of roads, airports, pipelines, building foundations, facilities for water storage, erosion control structures, drainage

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systems, and sewage disposal systems. Among the properties most important to engineers are permeability, shear strength, compaction characteristics, grain size, plasticity, and reaction (pH). Also important are the depth to bedrock and the topography.

Information in this soil survey can be used to-

1. Make studies that will aid in selecting and developing sites for industrial, business, residential, and recreational uses.
2. Develop information for the design of drainage and irrigation systems, farm ponds, diversion terraces, and other structures for soil and water conservation.
3. Make preliminary evaluations that will aid in selecting locations for highways and airports and in planning detailed surveys of the soils at the site.
4. Locate possible sources of sand, gravel, and quarry rock.
5. Correlate performance of engineering structures with soil mapping units to develop information that will be useful in designing and maintaining such structures.
6. Determine the suitability of soils for cross-country movement of vehicles and construction equipment.
7. Supplement information obtained from published maps, reports, and aerial photographs for the purpose of making maps and reports that can be used readily by engineers.
8. Develop other preliminary estimates for construction purposes pertinent to a particular area.

With the use of the soil map for identification, the engineering interpretations reported here can be useful for many purposes. It should be emphasized that they do not eliminate the need for sampling and testing at the site for design and construction of specific engineering works. Additional investigation is especially important at the site of works involving heavy loads or excavations deeper than the depths of layers here reported. Even in these situations, the soil map is useful for planning more detailed field investigations and for suggesting the kinds of problems that may be expected.

Much of the information in this section is presented in the form of tables. Table 5 gives estimated engineering properties of the soils, and table 6 gives engineering interpretations for several uses.

Engineering classification systems

Two systems of classifying soils for engineering purposes are in general use. They are described in the PCA Soil Primer (7). Classification of the soils of the Benton County Area according to both of these systems is given in this survey.

The Unified system of soil classification was developed by the Waterways Experiment Station, Corps of Engineers (15). In this system, soil classification is based on texture and plasticity and performance as construction material. In the Unified system SW and SP are clean sands, SM and SC are sands with fines of silt and clay, ML and CL are silts and clays of low liquid limit, and MH and CH are silts and clays of high liquid limit. If soils are on the borderline between two classifications, a joint classification symbol is used, for example, SP-SM.

The system used by the American Association of State Highway Officials (AASHO) (1) is based on field performance of soils in highways. In this system, soil materials are classified into seven principal groups, designated A-1 through A-7. The best materials for use in highway subgrades (gravelly soils of high bearing capacity) are classified as A-1, and the poorest (clayey soils having low strength when wet) are classified A-7.

Estimated properties

Estimates of some of the properties of the soils of the Benton County Area are given in table 5.

Permeability indicates the rate at which water moves through soil material that is not compacted. The estimates are based on soil texture, structure, and porosity. Available water capacity is an estimate of the amount of water available to plants. The estimates of permeability and available water capacity are especially significant in planning irrigation and drainage systems.

A seasonally high water table is a problem in only a few soils in this survey Area. The soils and land types that have a seasonally high water table are as follows
Pasco soils, Riverwash, Umapine soils, and Wamba soils. In addition, some areas of Esquatzel and Burbank soils that occur near streams or in seepage areas are affected by a high water table.

Corrosivity is closely related to reaction, drainage, and electrical conductivity. Generally, soils that have poor aeration, a high pH value, and high electrical conductivity are corrosive to metal conduits. Soils that have a low pH value are more corrosive to concrete conduits. In both cases, corrosion is more rapid when the moisture content of the soil is high.

Engineering interpretations

Table 6 gives engineering interpretations based on the soil properties described in table 5. These interpretations are general and will not take the place of examination and evaluation of the soil at the exact site of a planned engineering project.

Piping is frequently mentioned as a soil feature affecting the construction of embankments for dikes, levees, and farm ponds. As used in such instances, the word refers to progressive internal erosion within embankments and foundations. If piping occurs, soil material is removed by water under pressure. If enough soil material is removed, failure results.

Cracking, also mentioned as a soil feature affecting the construction of embankments for dikes, levees, and farm ponds, is a result of differential settlement of earth fills. Such settlement is caused by variation in the material. Differences in the height of the embankment or compression of the underlying strata may cause the formation of cracks through the embankment. Such cracks encourage concentration of seepage water, which may attain a velocity high enough to cause piping and consequent embankment failure. Cracking is associated with nonplastic soils that are unable to deform without cracking when settlement occurs.

Some features of a soil may be an advantage in one kind of engineering work and a hindrance in another.

For example, a rapidly permeable substratum would make a soil unsuitable as a site for a farm pond but suitable as a disposal field for a sewage disposal system, although there might be some danger of contaminating nearby water.

Susceptibility to frost action is an important consideration in engineering, particularly in selecting sites for roads and airports. For frost action to occur, there must be water in the soil and low temperatures must persist long enough for the water to freeze. The water may come from a high water table, it may be capillary water or water held in voids, or it may be water that infiltrates. The formation of ice is also influenced by topographic position, stratification of the parent material, transitions into cut sections, lateral flow of water from side cuts, localized pockets of perched ground water, and drainage conditions. In general, silt and very fine sand are the most susceptible to frost action. Coarse-grained material that contains little or no fine material is affected only slightly, if at all. Drainage to prevent the accumulation of water in soil pores helps to prevent accumulation of ice in the subgrade and subbase.

Three major factors that influence the suitability of soils for use in embankments are permeability, strength, and ease of compaction. Gravelly and sandy soils that contain little or no fine material are stable and pervious; they are easily compacted with crawler-type tractors and rubber-tired rollers. These soils are suitable for use in the pervious sections of earth embankments. Gravel and sand that contain fines vary, depending on gradation and on the nature of the fine fraction. These materials may be sufficiently impervious and stable to be used for the impervious sections of embankments. Silt and very fine sand are undesirable for rolled-fill construction and in general must be closely controlled in the field to secure the desired strength.

Frozen soil material should not be used in constructing embankments. If the material is gravelly or sandy and does not contain more than a small percentage of silt or clay, earthwork may be performed in winter, provided the material is compacted according to the required standards for such construction and frozen material is not included.

Wildlife

Before the Benton County Area was settled, the wildlife population was small. Good numbers of waterfowl, deer, sage grouse, and furbearers were to be found only along streams and around springs and potholes. The Columbia and Yakima Rivers provided resting place for migratory waterfowl in spring and fall. In the rest of the Area, there were few trees, and the native sagebrush and bunch grasses provided insufficient food and cover. Water was scarce, and the habitat was favorable only for such species as jackrabbits and desert mice, which can travel long distances for free water or can live without it.

After the Area was settled, wheatfields were planted and irrigation canals were built. These changes in environment favored an increase in the kinds and numbers of wildlife. Grain-eating species and those that need free water began to flourish. The ring-necked pheasant, Hungarian and chukar partridge, and California quail were introduced, and their numbers multiplied.

At the present time, waterfowl nest along the rivers. Mallards, pintails, and Canada geese feed in the many grain fields. Mourning dove inhabit irrigated areas and open range. A few deer can be found. There is a small population of sage grouse in the Rattlesnake Hills.

Of the introduced species, the larger populations of ring-necked pheasant are in the irrigated areas but there are smaller populations near water in the rest of the Area. California quail are numerous in brushy areas along streams and irrigation canals and in border areas between irrigated fields and open range. Hungarian partridge are found near grain fields and grassland. There are good populations of chukar partridge on rocky slopes, where cheatgrass is plentiful. The long-billed curlew is occasionally seen on rangeland near the rivers. This large shore bird is rare.

Open season for game birds in upland areas ordinarily lasts two months or more in fall. Both resident and nonresident sportsmen find good hunting.

Wildlife grouping

The soils of the Area have been grouped according to their suitability for producing specific kinds of habitat essential for supporting key species of wildlife. The key species are those that are important throughout the Area. In many places, a particular site is more suitable for minor species than for the key species.

The following criteria were used in rating the limitations of the soils for the key species.

Not limited to slightly limited: Minimum conservation management of the site is needed to support the key wildlife species.

Moderately limited: Average conservation management of the site is needed.

Severely limited: Intensive conservation management of the site is needed, and the development or management of such sites is not advisable.

Very severely limited: Conservation development or management of the site for the key species is not feasible or is not practical.

The following criteria were used in rating the limitations of the soils for elements of wildlife habitat.

Not limited to slightly limited: Wildlife habitat is generally easily established, improved, or maintained. There are few or no soil limitations, and satisfactory results seem assured.

Moderately limited: Wildlife habitat can be established, improved, or maintained, but there are moderate limitations that affect management. A moderate intensity of management and fairly frequent attention are needed to assure satisfactory results.

Severely limited: Wildlife habitat can be established, improved, or maintained, but there are severe limitations. Management is difficult and expensive, and intensive effort is needed. Results are uncertain.

Very severely limited: In most places wildlife habitat cannot be established, improved, or maintained, or it is impractical to attempt to do so. Unsatisfactory results are probable.

By BERT J. JAHN, wildlife biologist, Soil Conservation Service, assisted by JACK J. RASMUSSEN, soil scientist, Soil Conservation Service.

Descriptions of wildlife sites

The soils of the Benton County Area have been placed in nine wildlife sites. Each site is made up of soils that are similar in their suitability for wildlife habitat.

The names of the soil series represented are mentioned in the description of each site, but the listing of the series name does not necessarily indicate that all the soils of a series are in the same site. The wildlife site designation of any given soil can be learned by referring to the "Guide to Mapping Units."

WILDLIFE SITE 1

This site consists of very deep, medium-textured to moderately coarse textured soils of the Ellisforde, Esquatzel, Scooteney, Shano, and Warden series. These soils are generally used for dryland production of wheat, barley, and rye.

Ring-necked pheasant, California quail, and mourning dove are the key wildlife species. The limitations of the site are severe for pheasant and dove and very severe for quail. The limitations for elements of wildlife habitat are as follows: for grain crops, moderate; for standard hay and pasture mixtures, moderate; for standard windbreaks, very severe; for native grasses and forbs, moderate; for native brush, severe.

Water and cover are lacking in winter. The soils are suitable for pheasant if water is available at springs, wells, or wildlife watering places. Food is normally available in grain fields. Cover, however, is a limiting factor, because brushy plants can be grown only under intensive management. In summer these are important feeding areas for migrating waterfowl.

WILDLIFE SITE 2

This site consists of medium-textured or moderately coarse textured soils of the Burke, Esquatzel, Finley, Kennewick, Pasco, Prosser, Scooteney, Shano, and Warden series. The soils are irrigated, and they are suitable for many kinds of crops.

Ring-necked pheasant, California quail, and mourning dove are the key wildlife species. The limitations of the site are no more than slight for pheasant and moderate for quail and dove. The limitations for elements of wildlife habitat are as follows: for grain crops, none to slight; for standard hay and pasture mixtures, none to slight; for standard windbreaks, none to slight; for native grasses and forbs, none to slight.

Water is well distributed by irrigation canals and ditches, and the small fields of various crops provide a habitat for pheasant that is especially suitable. The pheasant population can be increased by raising more grain, especially corn, and by providing winter cover in the form of brushy hedgerows or windbreaks. California quail are abundant in brushy areas and in areas bordering rangeland. Orchards provide good habitat for mourning doves.

WILDLIFE SITE 3

This site consists of soils of the Burbank, Burke, Ellisforde, Finley, Hezel, Kennewick, Koehler, Prosser, Quincy, Shano, Starbuck, Umapine, and Warden series. The soils are shallow, and in many places they are steep or very steep. They are not irrigated.

Ring-necked pheasant, California quail, and mourning dove are the key wildlife species. The limitations of the site are severe for mourning dove and very severe for pheasant and quail. The limitations for elements of wildlife habitat are as follows: for grain crops, very severe; for standard hay and pasture mixtures, severe to very severe; for standard windbreaks, very severe; for native grasses and forbs, moderate to severe; for native brush, severe.

This site is only poorly suited to wildlife habitat. Areas that border better sites, however, provide food and cover for pheasant, quail, Hungarian partridge, and dove. In these areas existing brushy cover should be protected and watering places should be provided.

WILDLIFE SITE 4

This site consists of soils of the Burbank, Burke, Hezel, Kennewick, Quincy, Scooteney, Shano, Starbuck, Umapine, Wamba, and Warden series. The soils are shallow, medium textured and coarse textured, and strongly sloping.

Ring-necked pheasant, California quail, and mourning dove are the key wildlife species. The limitations of the site are moderate for all the key species. The limitations for elements of wildlife habitat are as follows: for grain crops, severe to very severe; for standard hay and pasture mixtures, none to slight; for standard windbreaks, none to moderate; for native grasses and forbs, none to slight.

These soils are suitable for irrigated hay, pasture, and orchards. Although they do not support so high a population of game birds as other irrigated soils, this is an important site for production of pheasant, quail, and dove. Protection of nests is especially important. Fence rows, odd areas, and other nesting cover should not be mowed or otherwise disturbed until after the young have hatched.

WILDLIFE SITE 5

This site consists of generally steep, stony, and rocky soils of the Burbank, Scooteney, and Starbuck series. The soils are used for range.

Ring-necked pheasant, California quail, and mourning dove are the key wildlife species. The limitations of the site are severe for all the key species. The limitations for elements of wildlife habitat are as follows: for grain crops, very severe; for standard hay and pasture mixtures, very severe; for standard windbreaks, very severe; for native grasses and forbs, moderate; for native brush, severe.

Although the soils are only poorly suited to the key wildlife species, they often produce enough food and cover for large numbers of chukar partridge. Installation of watering places at proper intervals increases the range of chukar.

WILDLIFE SITE 6

This site consists of very deep, medium-textured soils of the Walla Walla series. The soils are used almost entirely for dryland production of grain.

Ring-necked pheasant and California quail are the key wildlife species. The limitations of the site are moderate for pheasant and very severe for quail. The limitations for elements of wildlife habitat are as follows: for grain crops, moderate; for standard hay and pasture mixtures, moderate; for standard windbreaks, moderate; for native grasses and forbs, moderate; for native brush, severe.

Lack of cover and water limit suitability for pheasant. The limitations can be overcome by installation of watering places and by planting hedgerows or windbreaks. Caragana, Russian-olive, black locust, and Austrian pine are suitable for windbreaks.

WILDLIFE SITE 7

This site consists of moderately deep to very deep, medium-textured soils of the Endicott, Ritzville, and Willis series. The soils are used for dryland production of grain.

Ring-necked pheasant and California quail are the key wildlife species. The limitations of the site are severe for pheasant and very severe for quail. The limitations for elements of wildlife habitat are as follows: for grain crops, moderate; for standard hay and pasture mixtures, moderate; for standard windbreaks, severe; for native grasses and forbs, moderate; for native brush, severe.

Although this site does not offer cover for upland birds, it is useful for growing grain for food if cover is nearby and water is provided.

WILDLIFE SITE 8

This site consists of shallow, steep, and eroded soils of the Endicott, Ritzville, and Walla Walla series. It lacks water and cover, and except for those areas adjoining more favorable sites, has low value for wildlife habitat.

Ring-necked pheasant and California quail are the key wildlife species. The limitations of the site are severe for pheasant and very severe for quail. The limitations for elements of wildlife habitat are as follows: for grain crops, severe; for standard hay and pasture mixtures, severe; for standard windbreaks, severe; for native grasses and forbs, moderate; for native brush, severe.

WILDLIFE SITE 9

This site consists of steep, very stony and rocky, medium-textured soils of the Kiona and Lickskillet series.

Ring-necked pheasant and California quail are the key wildlife species. The limitations of the site are very severe for both key species. The limitations for elements of wildlife habitat are as follows: for grain crops, very severe; for standard hay and pasture mixtures, very severe; for standard windbreaks, very severe; for native grasses and forbs, moderate; for native brush, severe.

Chukar partridge is the most important of the wildlife species. Some sage grouse can be found, as well as a few deer. Installation of watering places increases the value of this site for wildlife habitat.

Windbreaks

Many of the farms in the Benton County Area need protection from strong winds. Well-planned and cared-for plantings of trees and shrubs check drifting snow, control wind erosion, protect livestock and buildings, and provide food and cover for wildlife. The trees and shrubs specified in table 7 can be grown on any of the irrigated soils if irrigation water is applied as needed. Most of these soils are well drained, deep, medium textured, and neutral to moderately alkaline.

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Three or more rows are generally used for windbreaks around farmsteads and feedlots. One or two are used for some field windbreaks. Dense, fast-growing shrubs are needed on the windward side of a multiple-row windbreak, one or more rows of tall evergreens or deciduous trees m the middle, and evergreens on the leeward side.

Caragana and Russian-olive are suitable shrubs for multiple-row plantings. Black locust is generally preferred for the center rows, where height is needed. Austrian pine and Scotch pine are the generally preferred evergreen trees. Douglas-fir, Norway spruce, blue spruce, and Rocky Mountain juniper are well suited if the moisture supply is sufficient. Most evergreens need protection from heat and wind the first year after planting. Protection can be provided by placing a supporting shingle on the south side of the tree.

On unprotected sandy soils, blowing sand will damage early-maturing crops, such as asparagus. Such crops need a dense windbreak of trees that leaf out early in spring. An example of a suitable windbreak is a row of Caragana on the windward side, then a row of Austrian pine or Rocky Mountain juniper.

High winds can cause damage to orchards. Protection is needed to reduce water transpiration through the leaves and to limit fruit-fall. Lombardy poplar, a fast-growing tree, is suitable for single-row windbreaks (fig. 8).

Windbreaks should be planted where they will intercept the wind but will not interfere with irrigation systems or farming operations. The soils should be plowed in fall and should be free of weeds because shrubs and trees cannot compete successfully with weeds and grass. Clean cultivation and irrigation are necessary to assure good survival. Windbreaks need protection from grazing animals and fire.

In addition to providing protection for fields and farmsteads, windbreaks improve the wildlife habitat. Caragana, bladdersenna, Russian-olive, and black locust provide food and shelter for game birds and songbirds.

Descriptions of the Soils

In this section the soil series and mapping units of the Benton County Area are described. The approximate acreage and proportionate extent of each mapping unit are given in table 8.

The series descriptions are in alphabetic order. Followng each series description is a fairly detailed description of one mapping unit of the series. This detailed description is followed by brief descriptions of the rest of the mapping units, first those that are not irrigated, then those that are irrigated.

In each series description is a short narrative description of a profile representative of the series. In the first mapping unit description is a much more detailed description of the same profile, which can be used by scientists, engineers, and others in making highly technical interpretations. The descriptions of the rest of the mapping units tell mainly how these units differ from the one described in detail.

Unless otherwise stated, the color names and color symbols given are for moist soils.

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All tables have been updated and are available as a separate document.

Figure 8.-A single-row windbreak of Lombardy poplar. The trees, which are 6 years old, were planted at 6-foot intervals to protect a roadside orchard. The soil is Quincy loamy sand, 0 to 2 percent slopes.

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Following the name of each mapping unit is a symbol in parentheses. This symbol identifies the mapping unit on the detailed soil map. At the end of the description of each mapping unit are listed the capability unit, the range site, and the wildlife site in which the mapping unit has been placed. The pages where these interpretive groups are described can be readily learned by referring to the "Guide to Mapping Units."

In the Benton County Area, the soils were mapped at two intensities. Soils within irrigated areas were mapped at high intensity, and those in unirrigated areas were mapped at medium intensity. The composition of the medium-intensity mapping units is more variable than that of the high-intensity units but has been controlled well enough to allow interpretations for the expected uses of the soils. The capability classification indicates whether the mapping unit is of medium or high intensity. Unirrigated soils were mapped at medium intensity and are in dryland capability units. Irrigated soils were mapped at high intensity and are in irrigated capability units. A separate "Guide to Mapping Units" is given for the soils mapped at each intensity.

For more general information about the soils, the reader can refer to the section "General Soil Map," in which the broad patterns of soils are described. Many of the terms used in the soil descriptions and other parts of the survey are defined in the Glossary.

Burbank Series

This series consists of excessively drained, coarse-textured soils on terraces along the Yakima and Columbia Rivers. These soils developed under grass and sagebrush in gravelly and stony alluvial deposits mantled with mixed alluvium and windblown sand. In some places solid basalt bedrock occurs at a depth of about 25 inches. These soils are nearly level to steep. Elevations range from 300 to 800 feet. The annual precipitation is 6 to 8 inches, the mean annual temperature is 53°F., and the frost-free season is about 180 days. Burbank soils are geographically associated with Quincy soils.

In a representative profile, the surface layer is very dark grayish-brown loamy fine sand to loamy sand about 16 inches thick. The next layer is very dark grayish-brown gravelly loamy sand. Gravel makes up about 45 percent, by volume, of this material. The material between about 35 inches and 60 inches consists of sandy gravel or basalt bedrock.

These soils are used mainly for range. A few areas are irrigated.

Burbank loamy fine sand, 0 to 15 percent slopes (BbC).-This soil occurs on old alluvial terraces. In most places the slope is about 4 percent. Included in mapping were a few areas of Quincy loamy sand, a few areas where the surface layer is gravelly or stony, and a few areas where bedrock is within about 25 inches of the surface.

This soil is excessively drained. Permeability is very rapid, and the water-holding capacity is low. Runoff is very slow. The hazard of water erosion is slight, and the hazard of wind erosion is severe. The effective rooting depth is less than 30 inches in most places. Fertility is low.

Representative profile in a grassy area, 1,000 feet west of Bombing Road between West Richland and U.S. Highway 12, NE1/4SE1/4 sec. 7, T. 9 N., R 28 E.

C1-0 to 5 inches, very dark grayish-brown (10YR 3/2) loamy fine sand, grayish brown (10YR 5/2) when dry; single grain; loose, nonsticky and nonplastic; abundant roots; mildly alkaline (pH 7.4) ; gradual, wavy boundary. 0 to 5 inches thick.

C2-5 to 16 inches, very dark grayish-brown (10YR 3/2) loamy sand, grayish brown (10YR 5/2) when dry; single grain; loose, nonsticky and nonplastic ; few roots; mildly alkaline (pH 7.6) ; gradual, wavy boundary. 10 to 30 inches thick.

IIC3-16 to 30 inches, very dark grayish-brown (10YR 3/2) gravelly loamy sand, light brownish gray (10YR 6/2) when dry; single grain; loose, nonsticky and nonplastic ; few roots; mildly alkaline (pH 7.8; strong effervescence; about 45 percent gravel, some of which is coated with lime-silica on the lower side; abrupt, wavy boundary. 10 to 20 inches thick.

IIIC4ca-30 to 35 inches, dark grayish-brown (10YR 4/2) very gravelly loamy sand, light brownish gray (10YR 6/2) when dry; single grain; loose, nonsticky and nonplastic; moderately alkaline (pH 8.3) ; violent effervescence; about 85 percent gravel and stones; some of the fragments are completely coated with lime-silica; gradual, wavy boundary. 4 to 20 inches thick.

IIIC5-35 to 60 inches, sandy gravel.

The surface horizon ranges from very (lark grayish brown (10YR 3/2) to dark brown (10YR 4/3) in color and froze loamy fine sand to fine sand in texture. In some places the Cca horizon is sufficiently developed that the gravel and stones are weakly cemented by lime and silica. The depth to sandy gravel is more than 20 inches. In places a layer of gravelly fine sandy loam, 2 to 6 inches thick, directly overlie, the sandy gravel. Gravel makes up less than 50 percent of the Cca horizon in a few places.

This soil is used for grazing. *Dryland capability unit VIIe-23; Sandy mange site; wildlife site 3.*

Burbank loamy fine sand, basalt substratum, 0 to 30 percent slopes (BdE).-Basalt bedrock is at a depth of 20 to 36 inches, but the profile of this soil is otherwise like that of Burbank loamy fine sand, 0 to 15 percent slopes, The soil is hummocky, and there are some blowouts. In most places the slope is about 5 percent. In some place small fragments of basalt are scattered throughout the soil. Included in mapping were small areas of soil as shallow as 10 inches over basalt bedrock, as well as small areas of Koehler loamy fine sand and of Quincy loamy sand, moderately shallow.

This soil is used for grazing. *Dryland capability unit VIIe-23; Sandy site; wildlife site 3.*

Burbank rocky loamy fine sand, basalt substratum, 0 to 30 percent slopes (BfE).-This soil has a profile like that of Burbank loamy fine sand, basalt substratum, 0 to 30 percent slopes. About 20 to 50 percent of the acreage consists of Rock outcrop. Included in mapping were a few small areas of deep sand that contains basalt stones and boulders dislodged from higher, rockier areas. Also included were a few small areas in which sandy gravel is at a depth of about 35 inches and a few stony areas on lowlands along the Yakima River.

This soil is used for range. *Dryland capability unit VIIs-20; Sandy range site; wildlife site 5.*

Burbank rocky loamy fine sand, 30 to 65 percent slopes (BkF).-This soil has a profile like that of Burbank loamy fine sand, basalt substratum, 0 to 30 percent slopes. About 50 percent of the acreage consists of basalt escarpments and talus. Included in mapping were small areas of deep loamy fine sand and areas of Dune land, as much as 40 acres in size.

This soil is used for range. *Dryland capability unit VIIs-20; Sandy range site; wildlife site 5.*

Burbank loamy fine sand, 0 to 2 percent slopes (BbA).-Gravelly loamy sand is at a depth of 20 to 36 inches, but the profile of this soil is otherwise like that of Burbank loamy fine sand, 0 to 15 percent slopes. Included in mapping were a few poorly drained areas along the Yakima River. Some of these wet areas are strongly affected by salts and alkali.

This soil is used mainly for hay and pasture. It is within an irrigation district and is irrigated in places. Application of water is difficult because permeability is very rapid and water-holding capacity is low. Although sprinkler irrigation systems are more suitable, surface or subsurface systems are used to irrigate some areas. Small, frequent applications of water are desirable. *Irrigated capability unit IVe-3; wildlife site 4.*

Burbank loamy fine sand, 2 to 15 percent slopes (BbD).-Gravelly loamy sand is at a depth of 20 to 36 inches, but the profile of this soil is otherwise like that of Burbank loamy fine sand, 0 to 15 percent slopes.

This soil is used mainly for hay and pasture. *Irrigated capability unit IVe-3; wildlife site 4.*

Burbank loamy fine sand, gravelly substratum, 0, to 2 percent slopes (BlA).-Except for the depth to gravelly loamy sand, this soil has a profile like that of Burbank loamy fine sand, 0 to 15 percent slopes. Gravelly loamy sand begins at a depth ranging from 10 to 20 inches.

This soil is used mainly for hay and pasture. *Irrigated capability unit IVe-3; wildlife site 4.*

Burbank loamy fine sand, gravelly substratum, 2 to. 15 percent slopes (BlD).-Except for the depth to gravelly loamy sand, this soil has a profile like that of Burbank loamy fine sand, 0 to 15 percent slopes. Gravelly loamy sand begins at a depth ranging from 10 to 20 inches.

This soil is used mainly for hay and pasture. *Irrigated capability unit IVe-3; wildlife site 4.*

Burke Series

This series consists of well-drained, shallow and moderately deep, medium-textured soils that have a hardpan. These soils occur on uplands midway up the slopes of the Rattlesnake Hills and in the Horse Heaven Hills. They developed under bunch grasses in windblown deposits of mixed origin. In most places they are underlain by basalt bedrock, but in some areas, by very gravelly material. They are gently sloping to steep. Elevations range from 1,000 to 1,300 feet. The annual precipitation is 6 to 9 inches, the mean annual temperature is 50°F., and the frost-free season is about 155 days. Burke soils are geographically associated with Shano soils.

In a representative profile, the uppermost 14 inches is dark grayish-brown silt loam. This material grades to grayish-brown, strongly calcareous silt loam. A hardpan consisting of indurated lime and silica begins at a depth of 25 inches.

These soils are used for range, for small grain in a crop-fallow system, and for irrigated crops.

Burke silt loam, 0 to 5 percent slopes (BmAB).-This soil (fig. 9) occurs mainly on broad ridgetops. In most places the slope is about 4 percent. Included in mapping were small areas of Rock outcrop, other rocky areas, and areas of a Shano silt loam.

This soil is well drained. Permeability is moderate, and the water-holding capacity is moderate to moderately high. Runoff is very slow to slow. The hazard of water erosion is slight, and the hazard of wind erosion is slight to moderate. The effective rooting depth is 10 to 36 inches. Tilth is good, and the soil is easily worked. Fertility is high.

Representative profile in a cultivated area, 500 feet north and 50 feet west of the intersection of Snipes and McDonald Roads, SEl/4SE1/4 sec. 31, T. 10 N., R. 25 E.

Ap1-0 to 5 inches, dark grayish-brown (10YR 4/2) silt loam, light brownish gray (10YR 6/2) when dry; weak, fine, granular structure; soft, friable, nonsticky and slightly plastic; plentiful roots; mildly alkaline (pH 7.6) ; abrupt, smooth boundary. 4 to 6 inches thick.

Ap2-5 to 7 inches, dark grayish-brown (10YR 4/2) silt loam, light brownish gray (10YR 6/2) when dry; weak, thick, platy structure; soft, friable, nonsticky and slightly plastic; plentiful roots; common fine pores; mildly alkaline (pH 7.7) ; clear, wavy boundary. 0 to 3 inches thick.

B2-7 to 14 inches, dark grayish-brown (10YR 4/2) silt loam, light brownish gray (10YR 6/2) when dry; weak, coarse,

Figure 9.-Profile of a Burke silt loam.

prismatic structure; soft, friable, slightly sticky and slightly plastic; plentiful roots; common fine pores; mildly alkaline (pH 7.8); abrupt, wavy boundary. 2 to 15 inches thick.

C1ca-14 to 25 inches, grayish-brown (2.5Y 5/2) silt loam, light gray (2.5Y 7/2) when dry; massive; soft, friable, slightly sticky and slightly plastic; plentiful roots; common fine pores; violent effervescence; moderately alkaline (pH 8.4) ; abrupt, wavy boundary. 4 to 16 inches thick.

IIC2casim-25 inches, indurated lime-silica hardpan, underlain by basalt bedrock.

The A horizon ranges from dark grayish brown (10YR 4/2) to dark brown (10YR 4/3) in color and from 4 to 7 inches in thickness. The texture of the surface layer ranges from silt loam to very fine sandy loam. The depth to the lime-silica cemented hardpan ranges from 20 to 36 inches. In some places fragments from the hardpan are scattered throughout the profile.

About half the acreage is cultivated, and half is used for grazing. Wheat, barley, and rye are grown in a crop-fallow system. *Dryland capability unit IVe-22; Loamy range site (6 to 9 inches precipitation); wildlife site 3.*

Burke silt loam, 30 to 65 percent slopes (BmF).-Included in the areas mapped as this soil were small areas that have been severely eroded by wind and water and small areas of Kiona very stony silt loam. Runoff is rapid to very rapid. The hazard of water erosion is severe to very severe.

This soil is used for grazing. *Dryland capability unit VIIe-21; Loamy range site (6 to 9 inches precipitation); wildlife site 3.*

Burke silt loam, 15 to 30 percent slopes, severely eroded (BmE3).-This soil has a profile like that of Burke silt loam, 0 to 5 percent slopes. In places all the surface layer has been lost through erosion. Included in mapping were small areas of Rock outcrop.

Runoff ordinarily is slow to medium, but it is rapid during occasional heavy rainstorms and after rapid snowmelt. The hazard of further water erosion is moderate to severe.

This soil is used for grazing. *Dryland capability unit VIe-20; Loamy range site (6 to 9 inches precipitation); wildlife site 3.*

Burke silt loam, shallow, 0 to 5 percent slopes (BnB).-This soil has a hardpan at a depth of 15 to 20 inches, but the profile is otherwise like that of Burke silt loam, 0 to 5 percent slopes. The water-holding capacity is low.

This soil is used for grazing. *Dryland capability unit VIIs-20; Shallow range site (6 to 9 inches precipitation); wildlife site 3.*

Burke very fine sandy loam, 0 to 15 percent slopes, eroded (BoD2).-Except for the texture of the surface layer, this soil has a profile like that of Burke silt loam, 0 to 5 percent slopes. The coarser texture is a result of wind erosion, which has blown out fine particles from the surface layer. The hazard of further wind erosion is moderate. Included in mapping were a few areas where the hardpan is at a depth of 10 to 20 inches.

This soil is used for grazing. *Dryland capability unit VIe-22; Loamy range site (6 to 9 inches precipitation); wildlife site 3.*

Burke silt loam, 0 to 2 percent slopes (BmA).-This soil has a profile like that of Burke silt loam, 0 to 5 percent slopes. Runoff is very slow, and the hazard of water erosion is slight.

Most of the acreage is irrigated. The main crops are sugar beets, asparagus, potatoes, small grain, corn, and mint. The soil is also suitable for grapes, hay, and pasture. *Irrigated capability unit IIs-2; wildlife site 2.*

Burke silt loam, 2 to 5 percent slopes (BmB).-This soil has a profile like that of Burke silt loam, 0 to 5 percent slopes. Runoff is slow, and the hazard of water erosion is slight to moderate.

Most of the acreage is irrigated. The main crops are sugar beets, asparagus, potatoes, small grain, corn, and mint. The soil is also suitable for grapes, hay, and pasture. *Irrigated capability unit IIe-20; wildlife site 2.*

Burke silt loam, 5 to 8 percent slopes (BmC).-This soil has a profile like that of Burke silt loam, 0 to 5 percent slopes. In most places, the slope is about 7 percent, but areas are included where the slope is as much as 15 percent. Runoff is medium, and the hazard of water erosion is moderate.

Most of the acreage is irrigated. The main crops are

sugar beets, asparagus, potatoes, small grain, corn, and mint. The soil is also suitable for grapes, hay, and potatoes. *Irrigated capability unit IIIe-2; wildlife site 4.*

Burke silt loam, shallow, 5 to 8 percent slopes (BnC).-Except for the depth to the hardpan, this soil has a profile like that of Burke silt loam, 0 to 5 percent slopes. In this soil the hardpan begins at a depth of 15 to 20 inches. Runoff is medium, and the hazard of water erosion is moderate to severe. The water-holding capacity is low. Shallow-rooted crops are suitable. *Irrigated capability unit IVe-2; wildlife site 4.*

Burke very fine sandy loam, 0 to 2 percent slopes, eroded (BoA2).-Except for the texture of the surface layer, this soil has a profile like that of Burke silt loam, 0 to 5 percent slopes. The coarser texture results from wind erosion, which has blown out fine particles from the surface layer. Runoff is very slow. The hazard of further wind erosion is moderate when the surface is bare. Tree fruits, grapes, hay, and pasture are suitable crops. *Irrigated capability unit IIIs-1; wildlife site 2.*

Burke very fine sandy loam, 2 to 5 percent slopes, eroded (BoB2).-Except for the texture of the surface layer, this soil has a profile like that of Burke silt loam, 0 to 5 percent slopes. Runoff is slow, and the hazard of water erosion is slight to moderate. The hazard of further wind erosion is moderate when the surface is bare. Tree fruits, grapes, hay, and pasture are suitable crops. *Irrigated capability unit IIIe-1; wildlife site 2.*

Burke very fine sandy loam, 5 to 8 percent slopes, eroded (BoC2).-Except for the texture of the surface layer, this soil has a profile like that of Burke silt loam, 0 to 5 percent slopes. Runoff is medium, and the hazard of wind and water erosion is moderate. Tree fruits, grapes, hay, and pasture are suitable crops. *Irrigated capability unit IVe-1; wildlife site 2.*

Burke very fine sandy loam, shallow, 0 to 8 percent slopes, eroded (BrC2).-Except for the texture of the surface layer and the depth to the hardpan, this soil has a profile like that of Burke silt loam, 0 to 5 percent slopes. In this soil the hardpan begins at a depth of 15 to 20 inches.

Runoff is very slow to medium, and the hazard of wind and water erosion is slight to moderate. The water-holding capacity is low. Fertility is low. Shallow-rooted crops are suitable. *Irrigated capability unit IVe-4; wildlife site 4.*

Dune Land

Dune land (Du) consists of very deep, loose fine sand that blows and shifts with the wind. The dunes vary in size and shape but are predominantly 5 to 20 feet high. Their long axis is oriented from southwest to northeast. Dune land occurs mainly in the southeastern part of the Area. It is barren and has no agricultural value. *Dryland capability unit VIIIe-20.*

Ellisforde Series

This series consists of well-drained, deep, medium-textured soils on uplands in the northeastern part of the Area. These soils developed under bunch grasses in a mantle of silty, wind-deposited material over lacustrine sediments. They are nearly level to moderately steep. Elevations range from 1,000 to 1,900 feet. The annual precipitation is 9 to 12 inches, the mean annual temperature is 50°F., and the frost-free season is about 150 days. Ellisforde soils are geographically associated with Ritzville soils.

In a representative profile, the surface layer is very dark grayish-brown to dark-brown silt loam about 13 inches thick. The subsoil and substratum are dark grayish-brown silt loam to a depth of 60 inches or more.

These soils are used mainly for production of wheat in a crop-fallow system.

Ellisforde silt loam, 0 to 5 percent slopes (EfB).-This soil occurs on uplands. In most places the slope is about 4 percent. Included in mapping were small areas of Ritzville silt loam and Warden silt loam.

This soil is well drained. Permeability is moderately slow, and the water-holding capacity is high. Runoff is slow to very slow. The hazard of water erosion is slight, and the hazard of wind erosion is slight to moderate. The effective rooting depth is more than 60 inches. Fertility is high.

Representative profile in a cultivated area, 150 feet west of Clodfelter Road and 1 mile south of irrigation canal, SE1/4SE1/4 sec. 14, T. 8 N., R. 28 E.

Ap1-0 to 4 inches, very dark grayish-brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) when dry; weak, fine, granular structure; soft, friable, nonsticky and slightly plastic; abundant roots; neutral (pH 7.1) ; abrupt, smooth boundary. 4 to 13 inches thick.

Ap2-4 to 13 inches, dark-brown (10YR 3/3) silt loam, brown (10YR 5/3) when dry; weak to moderate, coarse, prismatic structure; slightly hard, friable, nonsticky and slightly plastic; plentiful roots; common fine pores; neutral (pH 7.1) ; gradual, wavy boundary. 0 to 9 inches thick.

B2-13 to 20 inches, dark grayish-brown (10YR 4/2) silt loam, light brownish gray (10YR 6/2) when dry; weak, coarse, prismatic structure; soft, friable, slightly sticky and slightly plastic; plentiful roots; common fine pores; mildly alkaline (pH 7.4) ; abrupt, wavy boundary.

C1-20 to 29 inches, dark grayish-brown (10YR 4/2) silt loam; light brownish gray (10YR 6/2) when dry; massive; soft, friable, slightly sticky and slightly plastic; plentiful roots; few fine pores; slight effervescence; mildly alkaline (pH 7.6) ; abrupt, wavy boundary. Variable thickness.

IIC2ca-29 to 62 inches, dark grayish-brown (2.5Y 4/2) silt loam, light brownish gray (2.5Y 6/2) when dry; massive; some layers thinly laminated; hard, friable, slightly sticky and slightly plastic; few roots; few fine pores; disseminated and segregated mycelial lime; violent effervescence; moderately alkaline (pH 8.4).

The color of the A horizon ranges from very dark grayish brown (10YR 3/ 2) to dark brown (10YR 4/ 3) . The depth to the compact lacustrine sediments ranges from 15 to 36 inches. The C1 horizon does not occur in all profiles. The color of the IIC2ca horizon ranges from 10YR to 2.5Y in hue.

About 80 percent of the acreage is cultivated. Wheat and barley are grown in a crop-fallow system. *Dryland capability unit IIIc-20; Loamy range site (9 to 15 inches precipitation); wildlife site 1.*

Ellisforde silt loam, 15 to 30 percent slopes, severely eroded (EfE3).-Erosion has removed some, and in places all, of the surface layer, but otherwise, this soil has a profile like that of Ellisforde silt loam, 0 to 5 percent slopes. On north-facing slopes the depth to the substratum is generally about 36 inches. The hazard of water erosion is severe.

Runoff is normally medium, but it is rapid during occasional severe thunderstorms and after rapid snowmelt.

About 20 percent of the acreage is cultivated. The rest is used for grazing. *Dryland capability unit IVe-20; Loamy range site (9 to 15 inches precipitation); wildlife site 3.*

Endicott Series

This series consists of well-drained, shallow, and moderately deep, medium-textured soils on uplands in the Rattlesnake Hills. These soils developed under bunch grasses in silty, wind-worked deposits over basalt bedrock. They are gently sloping to steep. Elevations range from 2,200 to 3,500 feet. The annual precipitation is 11 to 15 inches, the mean annual temperature is 47°F., and the frost-free season is about 130 days. Endicott soils are geographically associated with Walla Walla soils.

In a representative profile, the surface layer is very dark brown to very dark grayish-brown silt loam about 9 inches thick. The subsoil consists of dark-brown silt loam about 9 inches thick. A lime-silica cemented hardpan begins at a depth of about 27 inches. Fragments from the hardpan are scattered throughout the profile in some places.

These soils are used for range and for small grain in a crop-fallow system.

Endicott silt loam, 0 to 5 percent slopes (EnB).-This soil occurs on uplands. In most places the slope is about 4 percent. Included in mapping were a few areas of Walla Walla silt loam.

This soil is well drained. Permeability is moderate, and the water-holding capacity is moderate to moderately high. Runoff is slow to very slow. When the soil is partly frozen, runoff on long slopes is more rapid and some erosion may take place. The hazard of water erosion is slight to moderate, and the hazard of wind erosion is slight. The effective rooting depth is 20 to 36 inches. Fertility is medium to high.

Representative profile in a cultivated area, 700 feet east of Crosby Road and 1 mile south of Pearl Road, SW1/4SW1/4 sec. 5, T. 10 N., R. 25 E.

Ap1-0 to 5 inches, very dark brown (10YR 2/2) silt loam, dark grayish-brown (10YR 4/2) when dry; weak, fine, granular structure; slightly hard, friable, slightly sticky and slightly plastic; abundant roots; common fine pores; mildly alkaline (pH 7.4) ; abrupt, smooth boundary. 4 to 6 inches thick.

Ap2-5 to 9 inches, very dark grayish-brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) when dry; weak, thick, platy structure; hard, friable, slightly sticky and slightly plastic; plentiful roots ; common fine pores; mildly alkaline (pH 7.4); gradual, wavy boundary. 3 to 5 inches thick.

B2-9 to 18 inches, dark-brown (10YR 3/3) silt loam, brown (10YR 3/3) when dry; weak, coarse, prismatic structure; soft, friable, slightly sticky and slightly plastic; plentiful roots; common fine pores; mildly alkaline (pH 7.6) ; abrupt, wavy boundary. 4 to 13 inches thick.

C1ca-18 to 27 inches, dark grayish-brown (10YR 4/2) silt loam, light brownish gray (10YR 6/2) when dry; massive; soft, friable, slightly sticky and slightly plastic; plentiful roots; common fine pores; moderately alkaline (pH 8.2); violent effervescence; abrupt, wavy boundary. 6 to 16 inches thick.

IIC2casim-27 inches +, white, indurated, lime-silica cemented hardpan underlain by basalt bedrock. There are some matted roots on the surface of the hardpan.

The depth to the lime-silica cemented hardpan ranges from 20 to 36 inches. In places fragments of the hardpan are scattered throughout the profile. The prominence of the B horizon lessens as the depth to the hardpan decreases.

About 75 percent of the acreage is cultivated. Wheat and barley are grown in a crop-fallow system. *Dryland capability unit IIIs-20; Loamy range site (9 to 15 inches precipitation); wildlife site 7.*

Endicott silt loam, 5 to 15 percent slopes (EnD).-This soil has a profile like that of Endicott silt loam, 0 to 5 percent slopes.

Runoff is slow to medium, and the hazard of water erosion is moderate. In some places erosion has removed 25 to 50 percent of the surface layer.

About 60 percent of the acreage is cultivated. The rest is used for grazing. *Dryland capability unit IIIe-20; Loamy range site (9 to 15 inches precipitation); wildlife site 7.*

Endicott silt loam, shallow, 0 to 40 percent slopes (EoE)-This soil has a profile like that of Endicott silt loam, 0 to 5 percent slopes, except that the depth to the lime-silica cemented hardpan ranges from 14 to 20 inches. In addition, the hardpan is generally less prominent, especially in areas adjacent to major drainageways. Much of the acreage is incised by gullies and is difficult to cross with farm machinery. Included in mapping were escarpments and rocky areas.

The water-holding capacity is low. Runoff is normally slow, but it is rapid during heavy rainstorms and after rapid snowmelt. The hazard of water erosion is moderate to severe.

This soil is suited to grazing. *Dryland capability unit VIe-20; Shallow range site (9 to 15 inches precipitation); wildlife site 8.*

Esquatzel Series

This series consists of deep, well-drained, medium-textured, nearly level to gently sloping soils on bottom lands. These soils developed under bunch grasses in alluvium. The areas are generally narrow and are incised by intermittent streams. They are scattered throughout the Area; the largest acreage is adjacent to the Yakima River, west of Prosser. Elevations range from 300 to 1,400 feet. The annual precipitation is 6 to 12 inches, the mean annual temperature is 50°F., and the frost-free season is about 150 days. Esquatzel soils are geographically associated with Ritzville, Shano, and Warden soils.

In a representative profile the soil is dark-brown to dark grayish-brown silt loam or very fine sandy loam to a depth of 60 inches or more. The material below a depth of about 35 inches is calcareous. In places the surface layer is fine sandy loam.

Although these soils are typically well drained, they are subject to seepage from surrounding irrigated soils, and, as a result, the depth to the water table varies. Also, some of the areas are subject to flash flooding as a result of runoff from higher soils. Unirrigated areas are used for grain or range.

Esquatzel silt loam, 0 to 5 percent slopes (EuAB).-This soil occurs as narrow, elongated areas on bottom

lands. In most places the slope is about 2 percent. Included in mapping were small areas of Warden silt loam, 0 to 5 percent slopes, and of Shano silt loam, 0 to 5 percent slopes.

This soil is well drained. Permeability is moderate, and the water-holding capacity is high. Runoff is slow to very slow. The hazard of either wind or water erosion is generally slight. In a few places, however, there is a hazard of severe gully erosion because the soil receives runoff from higher lying soils. The effective rooting depth is more than 60 inches. Fertility is high.

Profile in a cultivated area, 1/2 mile west of Richards Road and 50 feet north of Highway 22, NW1/4SE1/4 sec. 9, T. 8 N., R. 24 E. Profile is in an area mapped as Esquatzel silt loam, 0 to 2 percent slopes, but is representative of this soil.

Apl-0 to 4 inches, dark-brown (10YR 3/3) silt loam, brown (10YR 5/3) when dry; weak, fine, granular structure; soft, friable, nonsticky and slightly plastic; abundant roots ; neutral (pH 7.0) ; abrupt, smooth boundary. 3 to 11 inches thick.

Ap2-4 to 11 inches, dark-brown (10YR 3/3) silt loam, brown (10YR 5/3) when dry; moderate, medium, subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; plentiful roots; common fine pores; neutral (pH 7.1); clear, smooth boundary. 0 to 7 inches thick.

C1-11 to 35 inches, dark-brown (10YR 4/3) silt loam, pale brown (10YR 6/3) when dry; massive; soft, friable, slightly sticky and slightly plastic; few roots; common fine pores; mildly alkaline (pH 7.4) ; abrupt, wavy boundary. 15 to 25 inches thick.

C2-35 to 44 inches, dark grayish-brown (10YR 4/2) silt loam, light brownish gray (10YR 6/2) when dry; massive; soft, friable, slightly sticky and slightly plastic; few roots; few fine pores; moderately alkaline (pH 8.4) ; strong effervescence; gradual, wavy boundary. Variable thickness.

C3-44 to 55 inches, dark grayish-brown (10YR 4/2) very fine sandy loam, light brownish gray (10YR 6/2) when dry; massive; soft, friable, nonsticky and slightly plastic; few roots; few fine pores; moderately alkaline (pH 8.4) ; strong effervescence; abrupt, wavy boundary. Variable thickness.

C4-55 to 65 inches, dark grayish-brown (10YR 4/2) silt loam, light brownish gray (10YR 6/2) when dry; massive; soft, friable, slightly sticky and slightly plastic; moderately alkaline (pH 8.4); slight effervescence. Variable thickness.

The color of the Ap and C horizons is dark brown, dark grayish brown, or very dark grayish brown within the 10YR hue. In places strata of fine sandy loam occur in the C horizon. The depth to the calcareous layer is normally about 35 inches but ranges from 12 to 40 inches.

This soil is suited to dryland grain in a crop-fallow system, but because of its position, much of the acreage is used for range. *Dryland capability unit IIIc-20; Bottomland range site; wildlife site 1.*

Esquatzel fine sandy loam, 0 to 5 percent slopes (EsB).-Except that the surface layer is fine sandy loam and the subsoil is generally stratified with coarser sand, the profile of this soil is like that of Esquatzel silt loam, 0 to 5 percent slopes. In a few places the soil contains a layer of gravel. Included in mapping were small areas of Shano very fine sandy loam, 0 to 15 percent slopes, eroded, and Quincy loamy sand, 0 to 30 percent slopes. The hazard of wind erosion is moderate.

This soil is suited to dryland grain or range. It is generally used in the same way as adjoining areas. *Dryland capability unit IIIe-21; Bottomland range site; wildlife site 1.*

Esquatzel fine sandy loam, 0 to 2 percent slopes (EsA).-Except for the texture of the surface layer, the profile of this soil is like that of Esquatzel silt loam, 0 to 5 percent slopes. The hazard of water erosion is slight, and the hazard of wind erosion is moderate.

Suitable crops include hops, grapes, corn, alfalfa hay, and pasture. *Irrigated capability unit I-1; wildlife site 2.*

Esquatzel silt loam, 0 to 2 percent slopes (EuA).-This soil has a profile like that of Esquatzel silt loam, 0 to 5 percent slopes. Included in mapping were areas that are affected by seepage from higher lying irrigated soils, which results in variation in depth to the water table. The hazard of wind and water erosion is slight.

Suitable crops are mint, grapes, asparagus, corn, peas, sugar beets, hops, alfalfa hay, and pasture. *Irrigated capability unit I-1; wildlife site 2.*

Esquatzel silt loam, 2 to 5 percent slopes (EuB).-This soil has a profile like that of Esquatzel silt loam, 0 to 5 percent slopes. Included in mapping were a few areas where the surface layer is moderately coarse textured.

Runoff is slow. The hazard of water and wind erosion is slight to moderate.

Suitable crops include hops, grapes, corn, alfalfa hay, and pasture. *Irrigated capability unit IIe-2; wildlife site 2.*

Finley Series

This series consists of well-drained, nearly level to steep soils on old alluvial terraces and bottom lands of intermittent streams. These soils are underlain by gravel. They formed under bunch grasses in old alluvial material derived mainly from loess and basalt but partly from granite and quartzite. Elevations on terraces range from 300 to 800 feet. On some of the bottom lands, elevations are in excess of 1,200 feet. The annual precipitation is 6 to 9 inches, the mean annual temperature is 51°F., and the frost-free season is about 160 days. Finley soils are geographically associated with Burbank and Scooteney soils.

In a representative profile the surface layer is very dark grayish-brown fine sandy loam about 13 inches thick. The neat layer is dark grayish-brown very gravelly loam to a depth of 28 inches. Below a depth of 28 inches is sandy gravel and cobblestones. In places the surface layer is gravelly or stony.

Unirrigated areas of these soils are used for range.

Finley fine sandy loam, 0 to 15 percent slopes (FeC).-This soil occurs on old alluvial terraces. In most places the slope is about 2 percent. Included in mapping were small areas of Quincy loamy sand and Burbank loamy fine sand.

This soil is well drained. Permeability is moderately rapid above the gravel, and the water-holding capacity is low. Runoff is very slow to slow. The hazard of water erosion is slight, and the hazard of wind erosion is moderate. The effective rooting depth is about 30 inches. Fertility is low to moderate.

Profile in an area of native grasses, 50 feet east of Nine Canyon Road and 300 feet south of Teril Road, NW1/4SW1/4 sec. 27, T. 8 N., R. 30 E. Profile is in an area mapped as Finley stony fine sandy loam, 0 to 30 percent slopes, but is representative of this soil.

C1-0 to 3 inches, very dark grayish-brown (10YR 3/2) fine sandy loam, grayish brown (10YR 5/2) when dry; weak, fine, granular structure; soft, very friable, nonsticky and nonplastic ; abundant roots; mildly alkaline (pH 7.8) ; abrupt, smooth boundary. 2 to 6 inches thick.

C2-3 to 13 inches, very dark grayish-brown (10YR 3/2) fine sandy loam, grayish brown (10YR 5/2) when dry; massive; soft, very friable, nonsticky and nonplastic ; plentiful roots; mildly alkaline (pH 7.8) ; clear, wavy boundary. 4 to 19 inches thick.

IIC3-13 to 22 inches, dark grayish-brown (10YR 4/2) very gravelly loam, light brownish gray (10YR 6/2) when dry; massive; soft, very friable, slightly sticky and slightly plastic; few roots; common fine pores; mildly alkaline (pH 7.8) ; 60 percent gravel; some of the pebbles are coated with silica or lime-silica on the lower side; abrupt, wavy boundary. Variable thickness.

IIC3ca-22 to 28 inches, dark grayish-brown (10YR 4/2) very gravelly loam, light brownish gray (10YR 6/2) when dry; massive; soft, very friable, slightly sticky and slightly plastic ; moderately alkaline (pH 8.0) ; strong effervescence; 80 percent gravel and stones; many pebbles and stones are coated with lime-silica on the lower side. 5 to 15 inches thick.

IIIC4-28 to 60 inches, sandy gravel and cobblestones.

The C horizon ranges from very dark grayish brown (10YR 3/2) to dark brown (l0YR 4/3). In most places the depth to sandy gravel is less than 30 inches.

This soil is used for grazing. *Dryland capability unit VIe-22; Sandy Loam range site; wildlife site 3.*

Finley stony fine sandy loam, 0 to 30 percent slopes (FfE).-The profile of this soil is like that of Finley fine sandy loam, 0 to 15 percent slopes, except that the surface layer is stony and the depth to the gravelly substratum is generally less, but varies from place to place. Much of the acreage is on bottom lands of old streams, where it is subject to periodic flash flooding.

Runoff is very slow to medium. Wind erosion is not a hazard.

This soil is used for grazing. *Dryland capability unit VIIs-20; Sandy Loam range site; wildlife site 3.*

Finley fine sandy loam, 0 to 2 percent slopes (FeA).-The profile of this soil is like that of Finley fine sandy loam, 0 to 15 percent slopes. Runoff is very slow. Included in mapping were a few somewhat poorly drained areas on bottom lands along streams.

Suitable crops are mint, corn, peas, wheat, grapes, orchard crops, alfalfa hay, and pasture. The areas on bottom lands are suitable for pasture. *Irrigated capability unit IVs-2; wildlife site 2.*

Finley fine sandy loam, 2 to 5 percent slopes (FeB).-The profile of this soil is like that of Finley fine sandy loam, 0 to 15 percent slopes. Included in mapping were a few somewhat poorly drained areas on bottom lands.

Runoff is slow, and the hazard of water erosion is slight to moderate.

Suitable crops are mint, corn, peas, wheat, grapes, tree fruits, alfalfa hay, and pasture. The areas on bottom lands are suitable for pasture. *Irrigated capability unit IVe-1; wildlife site 2.*

Finley fine sandy loam, moderately deep, 0 to 2 percent slopes (FnA).-Except that the depth to very gravelly loam ranges from 20 to 28 inches, the profile of this soil is like that of Finley fine sandy loam, 0 to 15 percent slopes.

Runoff is very slow. The water-holding capacity is moderate. The abrupt boundary between the loamy material and the gravelly substratum restricts the movement of water, which results in a higher water-holding capacity than might otherwise be expected. Fertility is medium.

Suitable irrigated crops are mint, corn, peas, wheat, grapes, tree fruits, alfalfa hay, and pasture. *Irrigated capability unit IIIs-1; wildlife site 2.*

Finley fine sandy loam, moderately deep, 2 to 5 percent slopes (FnB).-The profile of this soil is like that of Finley fine sandy loam, 0 to 15 percent slopes, but it differs in the following respects: the slope is 2 to 5 percent, and the depth to very gravelly material ranges from 20 to 28 inches.

Runoff is slow, and the hazard of water erosion is moderate. The water-holding capacity is moderate. Fertility is medium.

Suitable irrigated crops are mint, corn, peas, wheat, grapes, tree fruits, alfalfa hay, and pasture. *Irrigated capability unit IIIe-1; wildlife site 2.*

Finley fine sandy loam, 5 to 15 percent slopes (FeD).-Except that the depth to very gravelly material ranges from 10 to 36 inches, the profile of this soil is like that of Finley fine sandy loam, 0 to 15 percent slopes.

Runoff is medium to rapid, and the hazard of water erosion is moderate to severe. The water-holding capacity is low to moderate.

Hay and pasture are well suited. Row crops are not generally grown. *Irrigated capability unit IVe-1; wildlife site 2.*

Finley gravelly fine sandy loam, 2 to 5 percent slopes (FgB).-Except for the texture of the surface layer, the profile of this soil is like that of Finley fine sandy loam, 0 to 15 percent slopes. The depth to the very gravelly material varies, but it is generally about 22 inches. Fertility is low. Hay and pasture are suitable crops. *Irrigated capability unit IVe-1; wildlife site 2.*

Hezel Series

This series consists of deep, well-drained soils on hummocky or dunelike terraces, mostly at the lower elevations in the Horse Heaven Hills. These soils developed under grass, sagebrush, and rabbitbrush in a mantle of windblown sand over silty lacustrine sediments. They are gently sloping to steep. Elevations range from 500 to 1,000 feet. The annual precipitation is 6 to 8 inches, the mean annual temperature is 51°F., and the frost-free season is about 155 days. Hezel soils are geographically associated with Quincy and Warden soils.

In a representative profile, the surface layer is very dark grayish-brown to dark-brown loamy fine sand or loamy very fine sand to a depth of about 16 inches. The underlying material is grayish-brown or dark grayish-brown stratified silt loam to a depth of 60 inches or more. The material below a depth of about 16 inches is calcareous.

Unirrigated areas of these soils are used for range.

Hezel loamy fine sand, 0 to 30 percent slopes (HeE).-This soil is on terraces. In most places the slope is about 6 percent. Included in mapping were a few small areas of Warden silt loam, Quincy loamy sand, and Dune land.

This soil is well drained. Permeability is rapid in the surface layer, but moderately slow in the substratum. The water-holding capacity is moderately high. Runoff is very

Figure 10.-An area of Hezel loamy fine sand. Blowouts are common on this soil. They are oriented to the northeast because the prevailing strong winds are from the southwest.

slow to slow. The hazard of water erosion is slight, and the hazard of wind erosion is severe. The effective rooting depth is more than 60 inches. Fertility is low.

In places wind erosion has removed enough soil material that the lake sediments are exposed (fig. 10) , and in other places, gravelly material has accumulated. In areas where sediments are exposed, the surfaces are commonly known as desert floor.

Representative profile in a grassy area, 175 feet west of Highway 221 and 2 3/4 miles south of Lenzie Road, NE1/4NE1/4 sec. 30, T. 6 N., R. 26 E.

C1-0 to 3 inches, very dark grayish-brown (10YR 3/2) loamy fine sand, grayish brown (10YR 5/2) when dry; single grain; loose, nonsticky and nonplastic ; abundant roots; mildly alkaline (pH 7.4) ; abrupt, wavy boundary. 0 to 5 inches thick.

C2-3 to 16 inches, dark-brown (10YR 3/3) loamy very fine sand, brown (10YR 5/3) when dry; massive; soft, very friable, nonsticky and nonplastic ; plentiful roots; mildly alkaline (pH 7.6) ; abrupt, wavy boundary. 10 to 30 inches thick.

IIC3ca-16 to 26 inches, grayish-brown (2.5Y 5/2) silt loam, light brownish gray (2.5Y 6/2) when dry; laminated; angular blocky structure; hard, friable, slightly sticky and slightly plastic; plentiful roots, mostly matted on ped surfaces; common fine pores; moderately alkaline (pH 8.4) ; violent effervescence; abrupt, wavy boundary. 8 to 15 inches thick.

IIC4-26 to 64 inches, dark grayish-brown (10YR 4/2) silt loam, light brownish gray (10YR 6/2) when moist; massive; slightly hard, friable, nonsticky and slightly plastic; few roots; few fine pores; moderately alkaline (pH 8.4) ; strong effervescence and violent effervescence on segregated mycelial lime; gradual, wavy boundary. Many feet thick.

The color of the C1and C2 horizons ranges from very dark grayish brown (10YR 3/2) to dark brown (10YR 4/3), and the texture, from loamy very fine sand to fine sand. Granite boulders are common in some places. The sediments consist of soft to hard, stratified sandy loam or loamy sand. In many places they are dissected by vertical or diagonal, laminated, elastic dikes.

Most of the acreage is used for range. *Dryland capability unit VIIe-23; Sandy range site; wildlife site 3.*

Hezel loamy fine sand, 0 to 2 percent slopes (HeA).- This soil has a profile like that of Hezel loamy fine sand, 0 to 30 percent slopes. Most of the acreage is irrigated. Included are a few somewhat poorly drained areas. Some of these areas are strongly affected by salts and alkali.

Hay and pasture are well suited. Tree fruits and grapes are suited if a cover crop is kept on the soil. *Irrigated capability unit IVe-3; wildlife site 4.*

Hezel loamy fine sand, 2 to 15 percent slopes (HeD).- The profile of this soil is like that of Hezel loamy fine sand, 0 to 30 percent slopes. Included in mapping were small areas of Quincy loamy sand, 2 to 15 percent slopes. Runoff is slow to medium. The hazard of water erosion is slight to moderate.

Hay and pasture are suitable irrigated crops. Tree fruits and grapes are suitable if a cover crop is maintained. *Irrigated capability unit IVe-3; wildlife site 4.*

Kennewick Series

This series consists of well-drained, deep, medium-textured soils, mainly on terraces within the irrigated area south of Kennewick. These soils developed under bunch grasses in lacustrine material. They are nearly level to steep. Elevations range from 500 to l00 feet. The annual precipitation is 6 to 9 inches, the mean annual temperature is 50° F., and the frost-free season is about 155

clays. Kennewick soils are geographically associated with Scooteney and Warden soils.

In a representative profile the soil is dark grayish-brown or grayish-brown silt loam to a depth of 12 inches. Below this, to a depth of 60 inches or more, is dominantly grayish-brown, laminated silt loam. These soils are characteristically strongly calcareous throughout. In places granite boulders are common.

These soils are used mainly for irrigated crops.

Kennewick silt loam, 0 to 2 percent slopes (KeA).-This soil occurs on uplands. It is strongly calcareous. Included in mapping were small areas of Warden silt loam.

Permeability is moderately slow, and the water-holding capacity is high. Runoff is very slow, and the hazard of rind and water erosion is slight. The effective rooting depth is about 20 inches. Fertility is medium.

Representative profile, at a point 100 feet north and 400 feet west of the intersection of Olympia Street and West 36th Avenue, SE1/4SE1/4NE1/4 sec. 14, T. 8 N., R. 29 E.

A1-0 to 2 inches, dark grayish-brown (10YR 4/2) silt loam, grayish brown (10YR 5/2) when dry; vesicular; weak, thin, platy structure; soft, friable, nonsticky and slightly plastic; abundant roots; strong effervescence; moderately alkaline (pH 8.2); abrupt, smooth boundary. 1 to 5 inches thick.

C1-2 to 12 inches, grayish-brown (2.5Y 5/2) silt loam, light gray (2.5Y 7/2) when dry; massive; slightly hard, friable, slightly sticky and plastic; plentiful roots; violent effervescence; moderately alkaline (pH 8.4) ; gradual, wavy boundary. 4 to 12 inches thick.

C2-12 to 19 inches, grayish-brown (2.5Y 5/2) silt loam, light gray (2.5Y 7/2) when dry; finely laminated; slightly hard, friable, slightly sticky and plastic; few roots; few fine tubular pores; violent effervescence; moderately alkaline (pH 8.4); abrupt, wavy boundary. 4 to 14 inches thick.

C3-19 to 32 inches, dark-gray (10YR 4/1) silt loam, light brownish gray (10YR 6/2) when dry; strong, fine lamination; hard, firm, slightly sticky and plastic; few fine tubular pores; disseminated and segregated mycelial lime; violent effervescence; strongly alkaline (pH 8.5) ; gradual, wavy boundary. 8 to 17 inches thick.

C4-32 to 40 inches, grayish-brown (2.5Y 5/2) silt loam, light gray (2.5Y 7/2) when dry; strong, fine lamination; hard, firm, sticky and plastic; few fine tubular pores; disseminated and segregated mycelial lime; violent effervescence; strongly alkaline (pH 8.8) ; gradual, wavy boundary. 6 to 12 inches thick.

C5-40 to 49 inches, dark grayish-brown (2.5Y 4/2) silt loam, light brownish gray (2.5Y 6/2) when dry; moderate, fine lamination; hard, firm, slightly sticky and plastic; few fine tubular pores; disseminated and segregated mycelial lime; violent effervescence; strongly alkaline (pH 8.8) ; abrupt, wavy boundary. 7 to 12 inches thick.

C6-49 to 62 inches, dark grayish-brown (2.5Y 4/2) silt loam, light brownish gray (2.5Y 6/2) when dry; massive; slightly hard, friable, slightly sticky and plastic; violent effervescence; moderately alkaline (pH 8.3).

The A1 horizon ranges from dark grayish brown (10YR 4/2) to grayish brown (10YR 5/2) in color and from 1 to 6 inches in thickness. The depth to the hard, firm, laminated horizon is commonly about 20 inches, but it ranges from 10 to 30 inches. The C horizon is commonly dissected by vertical or diagonal, laminated, elastic dikes.

Alfalfa, small grain, and grass-and-legume pasture are suitable irrigated crops when an irrigation system has been recently installed. After the soil has been irrigated several years, it is suitable for most crops grown in the Area. *Irrigated capability unit IIs-1; wildlife site 2.*

Kennewick silt loam, 15 to 30 percent slopes, severely eroded (KeE3).-This soil has a profile like that of Kennewick silt loam, 0 to 2 percent slopes. It is steeper than that soil, and in places it has lost all of the surface layer through erosion. Runoff is rapid, and the hazard of further water erosion is severe. Eroded shallow gullies that lead to deep gullies or intermittent streams are common. Included in snapping were a few small rocky or stony areas. This soil is used mainly for range. *Dryland capability unit VIe-20; Loamy range site (6 to 9 inches precipitation); wildlife site 3.*

Kennewick silt loam, 2 to 5 percent slopes (KeB).-The profile of this soil is like that of Kennewick silt loam, 0 to 2 percent slopes. Runoff is slow, and the hazard of water erosion is slight to moderate. Alfalfa, small grain, and grass-legume pasture are suitable irrigated crops where an irrigation system has been recently installed. After the soil has been irrigated several years, it is suitable for most crops grown in the Area. *Irrigated capability unit IIe-2; wildlife site 2.*

Kennewick silt loam, 5 to 8 percent slopes (KeC).-The profile of this soil is like that of Kennewick silt loam, 0 to 2 percent slopes. Runoff is medium, and the erosion hazard is moderate. Alfalfa, small grain, and grass-legume pasture are suitable irrigated crops where an irrigation system has been recently installed. After the soil has been irrigated several years, it is suitable for most crops grown in the Area. *Irrigated capability unit IIIe-2; wildlife site 2.*

Kennewick silt loam, 8 to 15 percent slopes (KeD).-The profile of this soil is like that of Kennewick silt loam, 0 to 2 percent sloes. Runoff is rapid, and the hazard of water erosion is severe. Alfalfa, small grain, and grass-legume pasture are suitable irrigated crops where an irrigation system has been recently installed. After the soil has been irrigated several years, it is suitable for most crops grown in the Area. *Irrigated capability unit IVe-2; wildlife site 4.*

Kiona Series

The Kiona series consists of well-drained, very stony, medium-textured soils underlain by basalt rubble. These soils developed under bunch grasses in a mixture of windlaid deposits and basalt residuum. They are on steep slopes, ridgetops, and terraces in the Rattlesnake Hills and in the Horse Heaven Hills. Elevations range from 800 to 2,500 feet. The annual precipitation is 7 to 12 inches, the mean annual temperature is 49° F., and the frost-free season is about 145 days. Kiona soils are geographically associated with Ritzville and Shano soils.

In a representative profile the surface layer is very dark grayish-brown to dark grayish-brown very stony silt loam about 4 inches thick. Below this is dark-brown very stony silt loam about 16 inches thick. Below a depth of about 20 inches is very gravelly loam or basalt rubble or bedrock. Basalt fragments, as much as 10 inches in diameter, occur in varying numbers throughout the soil. Rock outcrops are common.

Kiona soils are used for grazing.

Kiona very stony silt loam, 0 to 30 percent slopes (KnE).-This soil occurs in rough, broken areas in the Horse Heaven Hills and in the lower Rattlesnake Hills.

In most places the slope is about 15 percent. Included in mapping were areas that are shallow over basalt, areas of Rock outcrop, and, where the slope is 5 percent or less, small areas of Ritzville, Shano, and Warden silt loams.

Drainage is good. Permeability is moderate, and the water-holding capacity is low. Runoff is very slow to medium, except during heavy rainstorms and after snowmelt, when it is rapid. The hazard of water erosion is slight to moderate. The effective rooting depth is about 30 to 60 inches. Fertility is low.

Representative profile in an area of virgin grassland, 1 mile east of Gibbon, SE1/4NW1/4 sec. 25, T. 9 N., R.. 25 E.

A1-0 to 4 inches, very dark grayish-brown (10YR 3/2) very stony silt loam, grayish brown (10YR 5/2) when dry; weak fine, granular structure; soft friable, nonsticky and slightly plastic; abundant roots; mildly alkaline (pH 7.4) ; about 15 percent basalt fragments; abrupt, wavy boundary. 2 to 4 inches thick.

C1-4 to 20 inches, dark-brown (10YR 3/3) very stony silt loam, brown when dry; massive; soft, friable, nonsticky and slightly plastic; plentiful roots; common fine pores; mildly alkaline (pH 7.6) ; about 25 to 55 percent angular basalt gravel, cobblestones, and stones; abrupt, irregular boundary. 5 to 25 inches thick.

IIC2ca-20 to 60 inches, dark grayish-brown (10YR 4/2) very gravelly loam, light brownish gray (10YR 6/2) when dry; massive; soft, friable, slightly sticky and slightly plastic; few roots; violent effervescence; moderately alkaline (pH 8.2) ; about 70 percent angular basalt gravel, cobblestones, and stones.

The color of the A horizon ranges from very dark grayish brown (10YR 3/2) to dark grayish brown (10YR 4/2) . A calcareous layer occurs in some places. Basalt bedrock is at a depth of 30 inches in some places.

This soil is used for grazing. *Dryland capability unit VIIs-20; Shallow range site (9 to 15 inches precipitation); wildlife site 9.*

Kiona very stony silt loam, 30 to 65 percent slopes (KnF).-This soil has a profile like that of Kiona very stony silt loam, 0 to 30 percent slopes. Runoff is rapid to very rapid. The hazard of water erosion is severe to very severe. Included in mapping were many rock escarpments, as well as small areas of Ritzville silt loam and Shano silt loam.

This soil is used for grazing. *Dryland capability unit VIIs-20; Shallow range site (9 to 15 inches precipitation); wildlife site 9.*

Koehler Series

This series consists of somewhat excessively drained, coarse-textured soils on hummocky terraces, mainly at the lower elevations in the Horse Heaven Hills. These soils formed under grass, sagebrush, and rabbitbrush in a mantle of windblown sand overlying a lime-silica cemented hardpan. They are nearly level to sloping. Elevations range from 300 to 800 feet. The annual precipitation is 6 to 8 inches, the mean annual temperature is 53° F., and the frost-free season is about 165 days. Koehler soils are associated with Quincy soils.

In a representative profile the surface layer is very dark grayish-brown or dark grayish-brown loamy fine sand about 12 inches thick. Below this is dark grayish-brown, strongly calcareous loamy fine sand and sandy loam. At a depth of about 31 inches is an indurated lime-silica hardpan. In many places hardpan fragments are scattered throughout the profile. In areas that have been severely eroded by wind, hardpan fragments have accumulated on the surface.

Koehler soils are used for range.

Koehler loamy fine sand, 0 to 8 percent slopes (KoC).-Included in the areas mapped as this soil are small areas of Quincy loamy sand. The slope is generally about 4 percent.

This soil is somewhat excessively drained. Permeability is rapid, and the water-holding capacity is low. Runoff is very slow. The hazard of water erosion is slight, and the hazard of wind erosion is severe. The effective rooting depth is 15 to 36 inches. Fertility is low.

Representative profile in a grassy area, 75 feet east of intersection of Umatilla Road and Highway 14, SW1/4SW1/4 sec. 32, T. 6 N., R. 28 E.

C1-0 to 4 inches, very dark grayish-brown (10YR 3/2) loamy fine sand, grayish brown (10YR 5/2) when dry; single grain; loose, nonsticky and nonplastic ; abundant roots; mildly alkaline (pH 7.8) ; clear, wavy boundary. 0 to 5 inches thick.

C2-4 to 12 inches, very dark grayish-brown (10YR 3/2) loamy fine sand, light brownish gray (10YR 6/2) when dry; single grain; loose, nonsticky and nonplastic ; plentiful roots; moderately alkaline (pH 7.9) ; slight effervescence; clear, wavy boundary. 0 to 15 inches thick.

C3ca-12 to 25 inches, dark grayish-brown (10YR 4/2) loamy fine sand, light brownish gray (10YR 6/2) when dry; massive; soft, very friable, nonsticky and nonplastic ; few roots; moderately alkaline (pH 8.2) ; violent effervescence; abrupt, wavy boundary. Variable thickness.

C4ca-25 to 31 inches, dark grayish-brown (10YR 4/2) sandy loam, light gray (10YR 7/2) when dry; embedded fragments of lime-silica hardpan; massive; soft, very friable, nonsticky and nonplastic ; few matted roots; moderately alkaline (pH 8.2) ; violent effervescence; abrupt, wavy boundary. Variable thickness.

IIC5casim-31 inches, indurated lime-silica hardpan that does not break down completely in acid alone.

The texture of the C1 and C2 horizons ranges from loamy fine sand to fine sand, and the color from very dark grayish brown (10YR 3/2) to dark grayish brown (10YR 4/2). In places the profile is calcareous throughout. Lime-silica hardpan fragments, 1 inch or less in size, are scattered throughout the profile in varying quantities. The depth to the indurated lime-silica hardpan ranges from about 15 inches to about 36 inches.

This soil is used for range. *Dryland capability unit VIIe-23; Sandy range site; wildlife site 3.*

Lickskillet Series

This series consists of shallow, well-drained, medium-textured soils on steep canyon slopes and rolling ridgetops in the Rattlesnake Hills. These soils are very stony. They formed under bunch grasses in a mixture of windlaid deposits and basalt residuum. They are underlain by basalt bedrock. Elevations range from 2,200 to 3,500 feet. The annual precipitation is 11 to 15 inches, the mean annual temperature is 48° F., and the frost-free season is about 130 days. Lickskillet soils are associated with Walla Walla and Endicott soils.

In a representative profile the surface layer is very dark brown very stony silt loam about 5 inches thick. The subsoil is dark-brown or dark yellowish-brown, very stony heavy silt loam about 13 inches thick. Below this is basalt bedrock. Basalt fragments as much as 10 inches in

diameter occur in varying numbers throughout the profile.

These soils are used for grazing.

Lickskillet very stony silt loam, 0 to 30 percent slopes (LcE).-This soil occurs in the upper Rattlesnake Hills. In most places the slope is about 10 percent. Included in mapping were areas, making up about 5 percent of the acreage, where the soil is less than 8 inches deep over bedrock. Also included were areas, making up another 5 percent of the acreage, where the soil has a substratum of rubble or colluvium. In addition, small areas were included where the soil is more than 20 inches deep.

Drainage is good. Permeability is moderately slow, and the water-holding capacity is low. Runoff is normally slow to medium, but it is rapid during heavy rainstorms or after rapid snowmelt. The hazard of water erosion is moderate. The effective rooting depth is 10 to 20 inches. Fertility is low.

Representative profile in an area of virgin grassland, 800 feet south and 1 mile east of the intersection of Bennett and Jones Roads, NW1/4SW1/4 sec. 23, T. 11 N., R. 24 E.

A1-0 to 5 inches, very dark brown (10YR 2/ 2) very stony silt loam, grayish brown (10YR 5/2) when dry; weak, fine, granular structure; soft, friable, slightly sticky and slightly plastic; abundant roots; many, fine, vesicular pores; mildly alkaline (pH 7.6) ; about 10 percent basalt fragments; gradual, wavy boundary. 2 to 8 inches thick.

B21-5 to 11 inches, dark-brown (10YR 3/3), very stony heavy silt loam, brown (10YR 5/3) when dry; moderate, medium, subangular blocky structure; few thin coatings on ped surfaces; slightly hard, friable, sticky and plastic; plentiful roots; common fine pores; mildly alkaline (pH 7.6); approximately 40 percent basalt fragments; gradual, wavy boundary. 3 to 10 inches thick.

B22-11 to 18 inches dark yellowish-brown (10YR 3/4), very stony heavy silt loam, yellowish brown (10YR 5/4) when dry; moderate, medium, subangular blocky structure; few thin coatings on ped surfaces; slightly hard, friable, sticky and plastic; plentiful roots; common fine pores; mildly alkaline (pH 7.8); approximately 60 percent angular basalt fragments; abrupt, irregular boundary. 5 to 12 inches thick.

IIR-18 inches, basalt bedrock with some fractures. The rock fractures are coated with lime-silica and contain matted roots.

The color of the A horizon ranges from very dark brown to very dark grayish brown. The texture of the B horizon ranges from heavy silt loam to silty clay loam. The stoniness and the number of rock outcrops varies widely within short distances. The depth to basalt bedrock ranges from 10 to 20 inches; the average depth is about 18 inches.

This soil is used for grazing. *Dryland capability unit VIIs-20; Shallow range site (9 to 15 inches precipitation); wildlife site 9.*

Lickskillet very stony silt loam, 30 to 65 percent slopes (LcF).-The profile of this soil is like that of Lickskillet very stony silt loam, 0 to 30 percent slopes. In most places this soil occurs in steep canyons where the slope is about 35 percent. Included in mapping were areas, making up about 5 percent of the acreage, where the soil is less than 8 inches deep over bedrock. Also included were areas, making up another 5 percent of the acreage, where the soil has a substratum of rubble or colluvium. In addition, small areas were included where the soil is, more than 20 inches deep, as well as many rock escarpments.

Runoff is rapid to very rapid. The hazard of water erosion is severe to very severe.

This soil is used for grazing. *Dryland capability unit VIIs-20; Shallow range site (9 to 15 inches precipitation); wildlife site 9.*

Pasco Series

This series consists of deep, somewhat poorly drained, dominantly medium-textured soils on bottom lands along the Yakima and Columbia Rivers. These soils developed in recent alluvium deposited in ponded areas. They are level to nearly level. Elevations range from 250 to 600 feet. The annual precipitation is 6 to 8 inches, the mean annual temperature is 53° F., and the frost-free season is about 155 days. Pasco soils are geographically associated with Burbank soils.

Pasco soils consist of stratified layers of very dark grayish-brown or very dark brown silt loam and fine sandy loam to a depth of 60 inches or more. The surface layer is moderately alkaline, and the lower layers are mildly alkaline.

These soils are used mainly for hay and pasture. The vegetation includes sedges, saltgrass, and willows.

Pasco silt loam, 0 to 2 percent slopes (PcA).-This soil occurs on bottom lands. In most places the slope is about 1 percent. Included in mapping were small areas where the slope is as much as 5 percent. Also included were areas, mostly near West Richland or east of Kennewick, that are strongly affected by salts and alkali to a depth of about 20 inches. The vegetation in these areas consists mainly of saltgrass and greasewood.

This soil is somewhat poorly drained. Permeability is moderate, and the water-holding capacity is high. There is little or no erosion hazard. The water table is seasonally high. The effective rooting depth varies, but in some places it is more than 60 inches. Fertility is high.

Representative profile in a pasture, NW1/4SW1/4SW1/4 sec. 24, T. 9 N., R. 28 E.

Ap-0 to 6 inches, very dark grayish-brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) when dry; weak, fine and medium, granular structure; soft, friable, slightly sticky and slightly plastic; abundant roots; few, fine, faint mottles; slight effervescence; moderately alkaline (pH 8.2) ; clear, smooth boundary. 4 to 12 inches thick.

C1-6 to 20 inches, very dark grayish-brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) when dry; massive; soft, friable, slightly sticky and slightly plastic; plentiful roots; common, medium, faint mottles; slight effervescence; moderately alkaline (pH 8.4) ; clear, wavy boundary. 4 to 16 inches thick.

C2-20 to 33 inches, very dark gray (10YR 3/1) heavy silt loam, grayish brown (10YR 5/2) when dry; weak, medium, prismatic structure; slightly hard, friable, sticky and slightly plastic; plentiful roots; common fine pores; slight effervescence; moderately alkaline (pH 8.0) ; clear, wavy boundary. 4 to 16 inches thick.

C3-33 to 52 inches, very dark gray (10YR 3/1) very fine sandy loam, gray (10YR 5/1) when dry; massive; soft, very friable, slightly sticky and slightly plastic; plentiful roots; common, medium, faint mottles; slight effervescence; mildly alkaline (pH 7.8) ; clear, wavy boundary. 4 to 20 inches thick.

C4-52 to 62 inches, very dark brown (10YR 2/2) heavy silt loam, gray (10YR 5/1) when dry; massive; slightly hard, friable, sticky and slightly plastic; few roots; common fine pores; slight effervescence; mildly alkaline (pH 7.8).

The color of the Ap horizon ranges from very dark grayish brown (10YR 3/2) to very dark brown (10YR 2/2), and the texture from fine sandy loam to silt loam. The reaction ranges from neutral to moderately alkaline. In places the C horizon is stratified with lenses of loamy sand or gravelly sand about 1 to 3 inches thick.

This soil is used mainly for pasture. If drained and irrigated, it is suitable for corn, peas, and hay. *Irrigated capability unit IIIw-1; wildlife site 2.*

Pasco fine sandy loam, 0 to 2 percent slopes (PaA).-Except for the texture of the surface layer and stratification of the underlying material with fine sand, this soil has a profile like that of Pasco silt loam, 0 to 2 percent slopes. Included in snapping were small areas of Quincy loamy sand, 0 to 2 percent slopes. Also included were areas, mostly near West Richland or east of Kennewick, that are strongly affected by salts and alkali to a depth of about 20 inches. The vegetation in these areas consists mainly of saltgrass and greasewood.

The hazard of wind erosion is moderate if the soil has been drained and is in cultivation.

Most of the acreage is used for pasture. *Irrigated capability unit IIIw-1; wildlife site 2.*

Prosser Series

This series consists of well-drained, moderately deep, medium-textured soils on terraces. These soils formed under bunch grasses and sagebrush in silty alluvium and wind-deposited material overlying basalt bedrock. They are nearly level to steep. Elevations range from 500 to 800 feet. The annual precipitation is 6 to 9 inches, the mean annual temperature is 50° F., and the frost-free season is about 150 days. Prosser soils are geographically associated with Shano and Starbuck soils.

In a representative profile the surface layer is dark-brown or grayish-brown silt loam or very fine sandy loam 3 inches thick. The subsoil is dark-brown silt loam 10 inches thick. The substratum is dark-brown to dark grayish-brown silt loam that is very gravelly in the lower part. Basalt bedrock begins at a depth of 28 inches.

These soils are used for range and for irrigated crops.

Prosser silt loam, 0 to 30 percent slopes (PoE).-This soil occurs or low terraces. In most places the slope is about 4 percent. Included in mapping were small areas of a Starbuck silt loam, a few areas of Rock outcrop, and a few areas that are underlain by clay or tuffaceous sandstone.

Drainage is good. Permeability is moderate, and the water-holding capacity is moderate to moderately high. Runoff is slow. The hazard of wind erosion is moderate, and the hazard of water erosion is slight. Fertility is high.

Profile in an area of grassland, 900 feet south and 100 feet east of intersection, NE1/4NE1/4 sec. 18, T. 9 N., R. 26 E. Profile is in an area mapped as Prosser silt loam, 5 to 15 percent slopes, but is representative of this soil.

A-0 to 3 inches, dark-brown (10YR 3/3) silt loam, grayish brown (10YR 5/2) when dry; moderate, medium, platy structure breaking to weak, fine, granular; soft, friable, nonsticky and slightly plastic; abundant roots; few fine pores; neutral (pH 6.9) ; abrupt, smooth boundary. 2 to 6 inches thick.

B-3 to 13 inches, dark-brown (10YR 4/3) silt loam, brown (10YR 5/3) when dry; weak, coarse, prismatic structure; soft, friable, slightly sticky and slightly plastic; plentiful roots; few fine pores; neutral (pH 7.2) ; gradual, wavy boundary. 5 to 15 inches thick.

C1-13 to 25 inches, dark-brown (10YR 4/3) silt loam, brown (10YR 5/3) when dry; massive; soft, friable, slightly sticky and slightly plastic; plentiful roots; neutral (pH 7.3) ; abrupt, wavy boundary. Variable thickness.

IIC2-25 to 28 inches, dark grayish-brown (10YR 4/2) very gravelly silt loam, light brownish gray when dry; massive; soft, friable, slightly sticky and slightly plastic; matted roots between rock fragments; mildly alkaline (pH 7.4) ; 80 percent angular fragments of basalt; some of the fragments are coated with lime-silica on the lower side; abrupt, wavy boundary. 0 to 4 inches thick.

IIIR-28 inches, basalt bedrock.

The color ranges from dark brown to dark grayish brown throughout the profile. The depth to basalt bedrock ranges from 20 to 36 inches. In places the soil below a depth of about 24 inches is calcareous.

This soil is used for grazing. *Dryland capability unit IVe-22; Loamy range site (6 to 9 inches precipitation); wildlife site 3.*

Prosser very fine sandy loam, 0 to 15 percent slopes, eroded (PrD2).-Except for the texture of the surface layer, this soil has a profile like that of Prosser silt loam, 0 to 30 percent slopes. The coarser texture results from wind erosion, which has winnowed out the fine particles from the surface layer. The hazard of further wind erosion is moderate.

This soil is used for range. Much of the vegetation is needle-and-thread and cheatgrass. *Dryland capability unit VIe-22; Loamy range site (6 to 9 inches precipitation); wildlife site 3.*

Prosser silt loam, 0 to 2 percent slopes (PoA).-This soil has a profile like that of Prosser silt loam, 0 to 30 percent slopes. Included in mapping were small areas of Scooteney, Wamba, and Starbuck silt loams; a few areas of Rock outcrop; and a few areas that are strongly affected by salts and alkali.

Runoff is very slow. The hazard of water erosion is slight. Corn, peas, mint, wheat, hay, and pasture are suitable crops. *Irrigated capability unit IIs-2; wildlife site 2.*

Prosser silt loam, 2 to 5 percent slopes (PoB).-This soil has a profile like that of Prosser silt loam, 0 to 30 percent slopes. Included in mapping were a few areas of fine sandy loam, a few areas that are strongly affected by salts and alkali, and a few areas that are underlain by remnants of the Ellensburg geologic formation. In some of the included areas the substratum consists of strata of readily permeable sandstone or siltstone or deep, slowly permeable clay. Corn, mint, hay, and pasture are suitable crops. *Irrigated capability unit IIe-2; wildlife site 2.*

Prosser silt loam, 5 to 15 percent slopes (PoD).-This soil has a profile like that of Prosser silt loam, 0 to 30 percent slopes. In places the texture of the surface layer is sandy loam. Included in mapping were a few areas that are underlain by clay or tuffaceous sandstone of the Ellensburg geologic formation.

Runoff is medium to rapid, and the hazard of water erosion is moderate to severe. Hay and pasture are suitable crops. *Irrigated capability unit IVe-2, wildlife site 2.*

Quincy Series

The Quincy series consists of excessively drained, coarse-textured soils on hummocky or dunelike terraces mainly near West Richland and in the southern part of the Area. These soils formed under grass, sagebrush, and rabbitbrush; the parent material was windblown sand derived from granite, basalt, and quartzite. They are nearly level to steep. Elevations range from 300 to 1,100 feet. The annual precipitation is 6 to 8 inches, the mean annual temperature is 51° F., and the frost-free season is about 165 days. These soils are geographically associated with Burbank and Hezel soils.

Typically, Quincy soils consist of dark-brown to dark grayish-brown loamy sand to loamy fine sand to a depth of 60 inches or more. In places the soil is underlain by basalt at a depth of 20 to 36 inches.

These soils are used mainly for range, but some areas are irrigated.

Quincy loamy sand, 0 to 30 percent slopes (QuE).-This soil is deep and sandy. It is hummocky and dunelike, and there are some blowouts. Much of the acreage consists of long, narrow, duned ridges that extend considerable distances. In most places the slope is about 5 percent. Included in mapping were small areas of a Hezel loamy fine sand, areas of Dune land, and areas where bedrock is at a depth of 20 to 36 inches.

This soil is excessively drained. Permeability is very rapid, and the water-holding capacity is low. Runoff is very slow, and the hazard of wind erosion is severe. The effective rooting depth is more than 60 inches.

Representative profile in an area of grassland, 50 feet west of Umatilla Road and 4,500 feet north of intersection with Highway 14, SEl/4SE1/4 sec. 30, T. 6 N., R. 28 E.

C1-0 to 9 inches, dark grayish-brown (10YR 4/2) loamy sand, grayish brown (10YR 5/2) when dry; single grain; loose, nonsticky and nonplastic; abundant roots; mildly alkaline (pH 7.8); gradual, wavy boundary. 0 to 10 inches thick.

C2-9 to 35 inches, dark grayish-brown (10YR 4/2) loamy fine sand, grayish brown (10YR 5/2) when dry; single grain; loose, nonsticky and nonplastic ; few roots; mildly alkaline (pH 7.8) ; gradual, wavy boundary. 10 to 40 inches thick.

C3-35 to 40 inches, dark grayish-brown (10YR 4/2) loamy fine sand, light brownish gray (10YR 6/2) when dry; single grain; loose, nonsticky and nonplastic ; moderately alkaline (pH 8.2) ; abrupt, wavy boundary. 5 to 30 inches thick.

C4ca-40 to 65 inches, dark grayish-brown (10YR 4/2) loamy fine sand, light brownish gray (10YR 6/2) when dry; single grain; loose, nonsticky and nonplastic ; moderately alkaline (pH 8.4) ; violent effervescence.

The texture ranges from loamy fine sand to fine sand, and the color ranges from dark brown (10YR 3/3) to dark grayish brown (10YR 4/2). In some places the soil is noncalcareous throughout.

This soil is used for range. *Dryland capability unit VIIe-23; Sandy range site; wildlife site 3.*

Quincy loamy sand, moderately shallow, 0 to 30 percent slopes (QyE).-Except that it is underlain by basalt bedrock at a depth of 20 to 36 inches, this soil has a profile like that of Quincy loamy sand, 0 to 30 percent slopes. The areas are on low terraces. Elevations are 300 to 800 feet. This soil is used for range. *Dryland capability unit VIIe-23; Sandy range site; wildlife site 3.*

Quincy loamy sand, 0 to 2 percent slopes (QuA).-This soil has a profile like that of Quincy loamy sand, 0 to 30 percent slopes. It is suited to hay and pasture. Included were a few somewhat poorly drained areas, mainly near the Yakima River. Some of these areas are strongly affected by salts and alkali. *Irrigated capability unit IVe-3; wildlife site 4.*

Quincy loamy sand, 2 to 15 percent slopes (QuD).-This soil has a profile like that of Quincy loamy sand, 0 to 30 percent slopes. Irrigated hay and pasture are well suited. *Irrigated capability unit IVe-3; wildlife site 4.*

Ritzville Series

This series consists of well-drained, medium-textured soils on uplands in the Rattlesnake Hills and in Horse Heaven Hills. These soils developed under bunch grasses in silty, windblown deposits mixed with small amounts of volcanic ash. They are gently sloping to steep. Elevations range from 1,200 to 2,500 feet. The annual precipitation is 9 to 12 inches, the mean annual temperature is 48° F., and the frost-free season is about 140 days. Ritzville soils are geographically associated with Shano and Willis soils.

In a representative profile the surface layer is very dark grayish-brown to dark-brown silt loam or very fine sandy loam about 13 inches thick. The subsoil is dark-brown silt loam that extends to a depth of 36 inches, and the material underlying this layer is dark grayish-brown, calcareous silt loam to a depth of more than 60 inches.

These soils are used mainly for small grain in a crop-fallow system and for grazing.

Ritzville silt loam, 0 to 5 percent slopes (ReB).-This soil occurs on uplands. In most places the slope is about 4 percent. Included in mapping were a few areas where the slope is as much as 15 percent and small areas of Willis silt loam and of Ritzville very fine sandy loam, eroded.

Drainage is good. Permeability is moderate, and the water-holding capacity is high. Runoff is very slow to slow. The hazard of water erosion is slight, and the hazard of wind erosion is slight to moderate. The effective rooting depth is more than 36 inches (fig. 11). Tilth is good, and fertility is high.

Representative profile in a cultivated area, 100 feet north and 550 feet west of the intersection of Beck and Nine Canyon Roads, SE1/4NW1/4 sec. 30, T. 7 N., R. 30 E.

Ap-0 to 6 inches, very dark grayish-brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) when dry; weak, fine, granular structure; soft, very friable, nonsticky and slightly plastic; abundant roots; neutral (pH 6.9) ; abrupt, smooth boundary. 5 to 10 inches thick.

A1-6 to 13 inches, very dark grayish-brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) when dry; weak, coarse, prismatic structure; soft, friable, nonsticky and slightly plastic; plentiful roots; common fine pores; neutral (pH 7.2) ; gradual, wavy boundary. 6 to 17 inches thick.

B2-13 to 36 inches, dark-brown (10YR 3/3) silt loam, brown (10YR 5/3) when dry; weak, coarse, prismatic structure; soft, friable, nonsticky and slightly plastic; few roots; common fine pores; mildly alkaline (pH 7.6) ; abrupt, wavy boundary. 10 to 25 inches thick.

C1ca-36 to 51 inches, dark grayish-brown (10YR 4/2) silt loam, light brownish gray (10YR 6/2) when dry; weak, coarse, prismatic structure; soft, friable, nonsticky and slightly plastic; few roots; common fine pores; strong

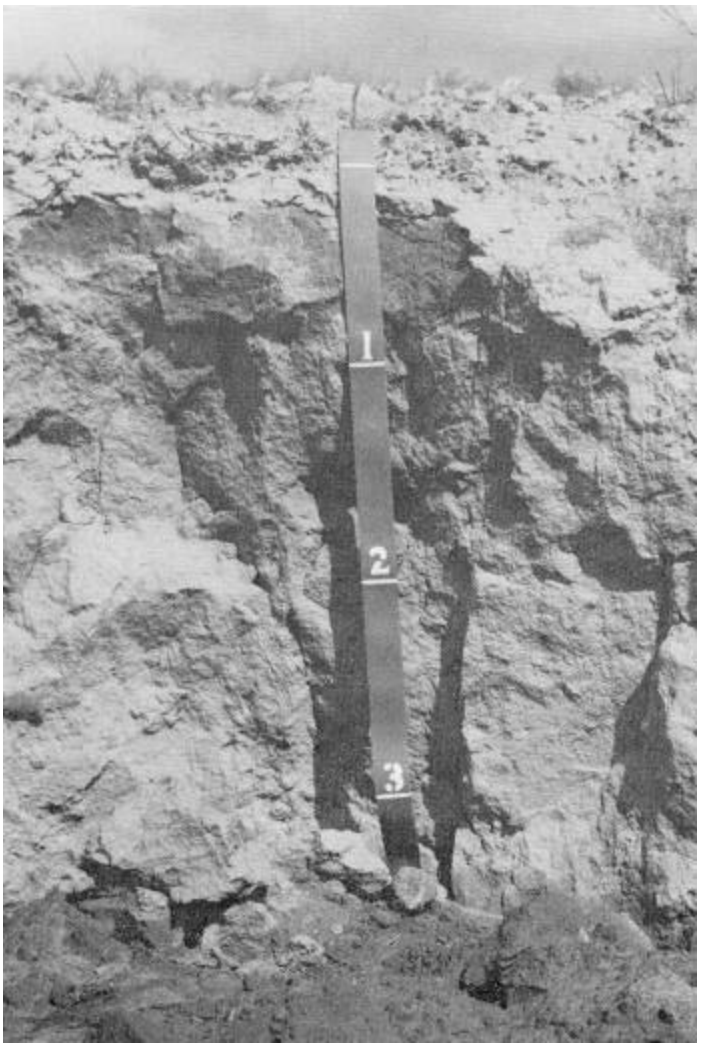


Figure 11-Profile of a Ritzville silt loam.

effervescence; moderately alkaline (pH 8.2); gradual, wavy boundary. 6 to 20 inches thick.

C2ca-51 to 67 inches, dark grayish-brown (10YR 4/2) silt loam, light brownish gray (10YR 6/2) when dry; massive; slightly hard, firm, nonsticky and slightly plastic; few roots; common fine pores; violent effervescence; moderately alkaline (pH 8.4).

The A horizon, when moist, ranges from very dark grayish brown (10YR 3/2) to dark brown (10YR 3/3). Generally, the depth to bedrock is more than 60 inches, but in places it is as little as 36 inches. The depth to lime is commonly more than 36 inches, but it is less than 36 inches in some of the areas where bedrock is within 60 inches of the surface. Firm aggregates of silt from overlying horizons have been deposited in insect burrows. These aggregates are as much as 1/2 inch wide and 4 inches long. They are common in the C horizon.

Most of the acreage is cultivated. Wheat, barley, and rye are grown in a crop-fallow system. In many of the cultivated areas a slightly hard, compact layer has formed just below tillage depth. *Dryland capability unit IIIe-20; Loamy range site (9 to 15 inches precipitation); wildlife site 7.*

Ritzville silt loam, 30 to 65 percent slopes (ReF).-Areas of this soil contain small areas of Rock outcrop, of escarpments, and of soils that have been severely eroded by wind or water.

Runoff is rapid to very rapid, and the hazard of water erosion is severe to very severe. The depth to free lime is more than 60 inches in solve places on north and northeast slopes.

This soil is used for grazing. *Dryland capability unit VIe-21; Loamy range site (9 to 15 inches precipitation); wildlife site 8.*

Ritzville silt loam, 15 to 30 percent slopes, severely eroded (ReE3).-Much of this soil occurs as narrow, elongated areas incised by shallow and deep gullies that are not easy to cross with farm machinery. Included in mapping were small areas of windblown sand and small areas of Rock outcrop.

Runoff is normally medium, but it is rapid during occasional heavy downpours or after rapid snowmelt.

Most of the acreage is used for grazing, but in places wheat is grown in a crop-fallow system. *Dryland capability unit IVe-20; Loamy range site (9 to 15 inches precipitation); wildlife site 8.*

Ritzville very fine sandy loam, 0 to 15 percent slopes, eroded (RfD2).-Wind erosion has altered the texture of the surface layer, but the profile of this soil is otherwise like that described for Ritzville silt loam, 0 to 5 percent slopes. In most places the slope is about 5 percent, but included in mapping were a few areas where the slope is as much as 25 percent. Also included were small duned areas, mainly along field borders or depressions.

Runoff is slow. The hazard of water erosion is slight, and the hazard of wind erosion is moderate.

This soil is suited to dryland grain or range. *Dryland capability unit IVe-21; Loamy range site (9 to 16 inches precipitation); wildlife site 8.*

Riverwash

Riverwash (Rh) consists mainly of alluvial sand and gravel along rivers and streams. These areas are flooded when the streams overflow and are exposed when the water is low. Most areas are bare of vegetation, but willows and cottonwoods are becoming established in places. They have no agricultural value. *Dryland capability unit VIIIw-20.*

Rock Outcrop

Rock outcrop (Ro) consists of outcrops of basalt bedrock. The areas are gently sloping to very steep, and there are some vertical escarpments. Except for scattered patches of vegetation in small pockets of soil, the areas are nearly barren. They have no agricultural value. *Dryland capability unit VIIIs-20.*

Scooteney Series

This series consists of well-drained, medium-textured soils on old alluvial terraces and on bottom lands along intermittent streams. These soils developed under bunch grasses in stony and gravelly alluvium and in silty, windblown deposits. They are nearly level to steep. Elevations range from 400 to 1,300 feet. The annual precipitation is

6 to 9 inches, the mean annual temperature is 50° F., and the frost-free season is about 150 days. Scooteney soils are geographically associated with Starbuck and Wamba soils.

In a representative profile the surface layer is dark grayish-brown silt loam about 4 inches thick. The subsoil is dark grayish-brown silt loam about 12 inches thick. The next layer is calcareous, dark grayish-brown silt loam. The underlying material, to a depth of 60 inches or more, consists of grayish-brown gravelly silt loam and dark-gray very gravelly loam.

Unirrigated areas are used for range. Irrigated areas are used for grapes, orchard crops, mint, hay, and pasture.

Scooteney silt loam, 0 to 5 percent slopes (ScAB).-This soil occurs on old alluvial terraces. In most places the slope is about 4 percent. Included in mapping were a few areas where the slope is as much as 15 percent and areas where the subsoil is gravelly. Also included were areas of Starbuck silt loam and of Wamba silt loam, 0 to 2 percent slopes.

Drainage is good. Permeability is moderate, and the water-holding capacity is moderately high. Runoff is very slow to slow, and the hazard of wind and water erosion is slight to moderate. The effective rooting depth is more than 36 inches (fig. 12). Fertility is high.

Profile in a grassy area, 700 feet east of Hinzerling Road and 100 feet north of railroad track, NE1/4NW1/4SW1/4 sec. 25, T. 9 N., R. 24 E. Profile is in an area mapped as Scooteney silt loam, gravelly subsoil, 2 to 5 percent slopes, but is representative of this soil.

A1-0 to 4 inches, dark grayish-brown (10YR 4/2) silt loam, brown (10YR 5/3) when dry; weak, very thick, platy structure; slightly hard, friable, nonsticky and slightly plastic; abundant roots; common fine pores; neutral (pH 7.2) ; gradual, wavy boundary. 3 to 6 inches thick.

B-4 to 16 inches, dark grayish-brown (10YR 4/2) silt loam, brown (10YR 5/3) when dry; weak, coarse, prismatic structure; slightly hard, friable, nonsticky and slightly plastic; plentiful roots; common fine pores; mildly alkaline (pH 7.4); abrupt, wavy boundary. 6 to 15 inches thick.

C1ca-16 to 21 inches, dark grayish-brown (2.5Y 4/2) silt loam, light brownish gray (2.5Y 6/2) when dry; weak, coarse, prismatic structure; slightly hard, friable, nonsticky and slightly plastic; plentiful roots; common fine pores; moderately alkaline (pH 8.2) ; violent effervescence; abrupt, wavy boundary. 0 to 14 inches thick.

IIC2ca-21 to 38 inches, grayish-brown (10YR 5/2) gravelly silt loam, light brownish gray (10YR 6/2) when dry; massive; slightly hard, friable, nonsticky and slightly plastic; plentiful roots; moderately alkaline (pH 8.2); violent effervescence; gradual, wavy boundary. 2 to 20 inches thick.

IIIC3-38 to 60 inches, dark-gray (10YR 4/1) very gravelly loam, gray (10YR 6/1) when dry; massive; soft, very friable, nonsticky and nonplastic; few roots; moderately alkaline (pH 8.2); strong effervescence; about 70 percent gravel.

The A1 horizon ranges from dark grayish brown (10YR 4/2) to dark brown (10YR 4/3) in color. In places angular stones and gravel are common throughout the profile. The structure of the B horizon ranges from weak, medium, subangular blocky to weak coarse, prismatic. The color of the C horizon ranges from 10YR to 2.5Y in hue. In places the substratum is weakly cemented with lime-silica.

This soil is used mainly for grazing. *Dryland capability unit IVe-22; Loamy range site (6 to 9 inches precipitation); wildlife site 1.*

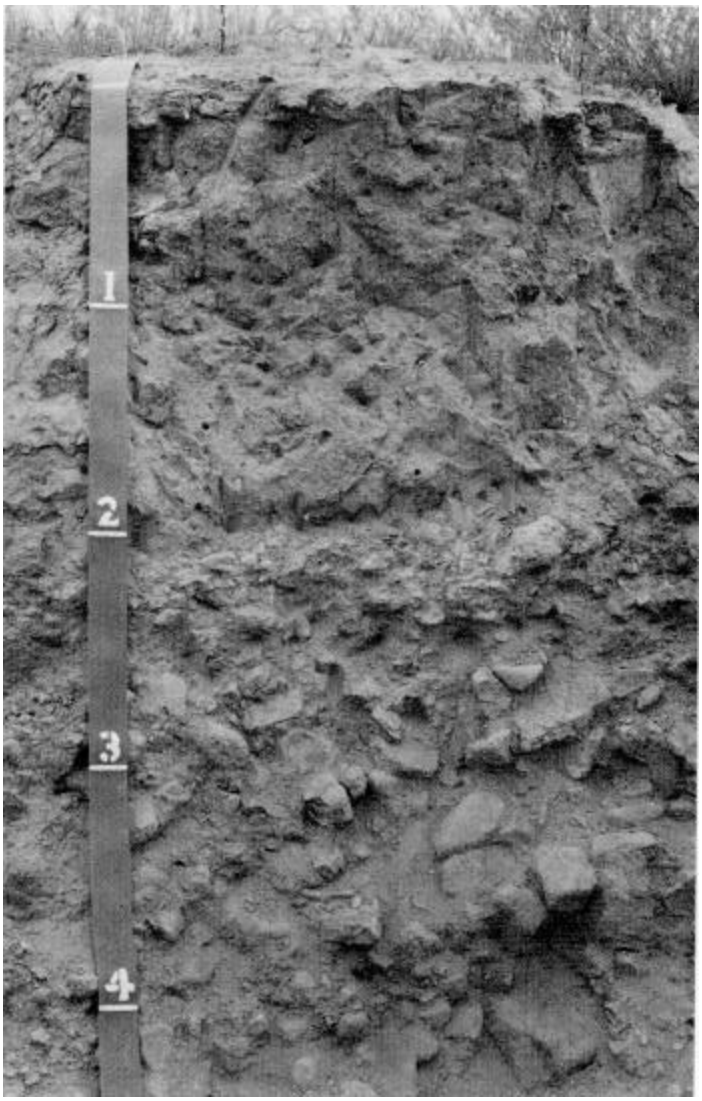


Figure 12.-Profile of a Scooteney silt loam.

Scooteney stony silt loam, 0 to 30 percent slopes (SeE).-This soil has a stony and gravelly surface layer, but its profile is otherwise like that of Scooteney silt loam, 0 to 5 percent slopes. In most places the slope is about 12 percent. Included are escarpments that form the banks of the Yakima River in some places.

Runoff is slow to medium. The erosion hazard is slight to moderate.

This soil is used for grazing. *Dryland capability unit VIIs-20; Loamy range site (6 to 9 inches precipitation); wildlife site 5.*

Scooteney gravelly silt loam, 2 to 5 percent slopes (SgB).-This soil has a gravelly surface layer, but its profile is otherwise like that of Scooteney silt loam, 0 to 5 percent slopes. Much of the gravel has been brought to the surface by deep tillage or leveling.

Runoff is slow. The erosion hazard is slight to moderate.

Grapes, tree fruits, hay, and pasture are suitable crops. *Irrigated capability unit IIIe-2; wildlife site 2.*

Scooteney silt loam, 0 to 2 percent slopes (ScA).-This soil has a profile like that of Scooteney silt loam, 0 to 5 percent slopes. Included in mapping were small areas of Scooteney silt loam, gravelly subsoil, and small areas of Finley fine sandy loam.

Runoff is very slow. The erosion hazard is slight.

Most of the acreage is irrigated. Tree fruits, grapes, mint, hay, and pasture are the main crops. *Irrigated capability unit IIs-2; wildlife site 2.*

Scooteney silt loam, 2 to 5 percent slopes (ScB).-This soil has a profile like that of Scooteney silt loam, 0 to 5 percent slopes.

Runoff is slow. The hazard of water erosion is slight to moderate.

Most of the acreage is irrigated. Tree fruits, grapes, mint, hay, and pasture are the main crops. *Irrigated capability unit IIe-2; wildlife site 2.*

Scooteney silt loam, 5 to 8 percent slopes (ScC).-This soil has a profile like that of Scooteney silt loam, 0 to 5 percent slopes. In most places the slope is about 7 percent.

Runoff is medium. The hazard of water erosion is moderate.

Suitable crops include tree fruits, hay, and pasture. *Irrigated capability unit IIIe-2; wildlife site 2.*

Scooteney silt loam, gravelly subsoil, 0 to 2 percent slopes (SdA).-Gravelly silt loam occurs at a depth of 10 to 20 inches in this soil, but the profile is otherwise like that of Scooteney silt loam, 0 to 5 percent slopes. Included in mapping were small areas of a Scooteney silt loam, a Scooteney gravelly silt loam, a Starbuck silt loam, and a Wamba silt loam. Also included were a few areas that are strongly affected by salts and alkali.

Runoff is very slow. The erosion hazard is slight.

Most of the acreage is irrigated. Tree fruits, grapes, mint, hay, and pasture are suitable crops. *Irrigated capability unit IIs-2; wildlife site 2.*

Scooteney silt loam, gravelly subsoil, 2 to 5 percent slopes (SdB).-Gravelly silt loam is at a depth of 10 to 20 inches, but the profile of this soil is otherwise like that of Scooteney silt loam, 0 to 5 percent slopes.

Runoff is slow. The hazard of water erosion is slight to moderate.

This soil is suited to tree fruits, grapes, mint, hay, and pasture. *Irrigated capability unit IIIe-2; wildlife site 2.*

Scooteney silt loam, gravelly subsoil, 5 to 15 percent slopes (SdD).-Gravelly silt loam is at a depth of 10 to 20 inches, but the profile is otherwise like that of Scooteney silt loam, 0 to 5 percent slopes.

Runoff is medium to rapid. The hazard of water erosion is moderate to severe.

This soil is suited to tree fruits, hay, and pasture. *Irrigated capability unit IVe-2; wildlife site 4.*

Shano Series

This series consists of well-drained, medium-textured soils on uplands in the Rattlesnake Hills and in the Horse Heaven Hills. These soils developed under bunch grasses in silty, windblown deposits. They are gently sloping to steep. Elevations range from 500 to 1,300 feet. The annual precipitation is 6 to 9 inches, the mean annual temperature is 50° F., and the frost-free season is about 150 days. Shano soils are geographically associated with Burke and Warden soils.

The surface layer is dark grayish-brown silt loam or very fine sandy loam about 6 inches thick. The subsoil is dark grayish-brown silt loam about 14 inches thick. Below this is dark-brown, grayish-brown, and brown silt loam. These soils are normally more than 60 inches deep, but in places they are underlain by basalt at a depth of 36 to 60 inches.

Unirrigated areas of these soils are used mainly for small grain in a crop-fallow system and for grazing. Irrigated areas are used for asparagus, sugar beets, hops, orchard crops, grapes, corn, mint, hay, and pasture.

Shano silt loam, 0 to 5 percent slopes (ShAB).-This soil occurs on uplands. In most places the slope is about 4 percent. Included in mapping were a few areas where the slope is as much as 15 percent. Also included were small areas of a Burke silt loam, an eroded phase of a Shano very fine sandy loam, and a Warden silt loam.

Drainage is good. Permeability is moderate, and the water-holding capacity is high. Runoff is very slow to slow. The hazard of water erosion is slight, and the hazard of wind erosion is slight to moderate. The effective rooting depth is 36 inches or more. Tilth is good, and fertility is high.

Representative profile in a cultivated area, 120 feet north and 1,050 feet west of the intersection of Crosby and Snipes Roads, SW1/4SE1/4SE1/4 sec. 36, T. 10 N., R. 24 E.

Ap-0 to 6 inches, dark grayish-brown (10YR 4/2) silt loam, light brownish gray (10YR 6/2) when dry; medium, fine, granular structure; soft, very friable, nonsticky and slightly plastic; abundant roots; neutral (pH 7.3) ; abrupt, smooth boundary. 5 to 8 inches thick.

B-6 to 20 inches, dark grayish-brown (10YR 4/2) silt loam, light brownish gray (10YR 6/2) when dry; weak, coarse, prismatic structure; soft, friable, nonsticky and slightly plastic; plentiful roots; common fine pores; mildly alkaline (pH 7.4) ; abrupt, wavy boundary. 8 to 18 inches thick.

C1-20 to 28 inches, dark-brown (10YR 4/3) silt loam, pale brown (10YR 6/3) when dry; massive; soft, friable, nonsticky and slightly plastic; plentiful roots; common fine pores; slight effervescence; moderately alkaline (pH 8.3) ; gradual, wavy boundary. 8 to 15 inches thick.

C2ca-28 to 49 inches, grayish-brown (10YR 5/ 2) silt loam, very pale brown (10YR 7/3) when dry; massive; slightly hard, friable, nonsticky and slightly plastic; plentiful roots; common fine pores; disseminated and segregated mycelial lime; violent effervescence; strongly alkaline (pH 8.6) ; abrupt, wavy boundary. 7 to 15 inches thick.

C3-49 to 56 inches, brown (10YR 5/3) silt loam, pale brown (10YR 6/3) when dry; massive; soft, friable, nonsticky and slightly plastic; few roots; common fine pores; strongly alkaline (pH 8.6); abrupt, smooth boundary. 7 inches to many feet thick.

IIR-56 inches, basalt bedrock, generally capped with lime-silica coating or cemented hardpan.

The A horizon ranges from dark grayish brown (10YR 4/2) to dark brown (10YR 4/3) in color. The depth to lime ranges from 17 to 34 inches. Segregated mycelial lime is lacking in the Cca horizon of some profiles. In some places hard concentric (Cicada) nodules occur in the C horizon. The depth to basalt bedrock ranges from 36 to more than 60 inches.

Most of the acreage is cultivated. Wheat, barley, and rye are grown in a crop-fallow system. *Dryland capability unit IVc-20; Loamy range site (6 to 9 inches precipitation); wildlife site 1.*

Shano silt loam, 30 to 65 percent slopes (ShF).- This soil has a profile like that of Shano silt loam, 0 to 5 percent slopes. Included in mapping were small, severely eroded areas and small areas of a Kiona very stony silt loam.

Runoff is rapid to very rapid. The hazard of water erosion is severe to very severe.

This soil is used for range. *Dryland capability unit VIIe-21; Loamy range site (6 to 9 inches precipitation); wildlife site 3.*

Shano silt loam, 15 to 30 percent slopes, severely eroded (ShE3).-This soil has lost part or all of its surface layer through erosion, but the profile is otherwise like that of Shano silt loam, 0 to 5 percent slopes. Much of the acreage consists of narrow, elongated areas incised by shallow and deep gullies that are difficult to cross with farm machinery. Included in mapping were small areas of a Kiona very stony silt loam, an eroded phase of a Shano very fine sandy loam, and a Quincy loamy sand.

Runoff is normally medium, but it is rapid during heavy rainstorms or after rapid snowmelt. The hazard of further water erosion is moderate to severe.

Most of the acreage is used for grazing, but wheat is grown in a crop-fallow system in a few areas. *Dryland capability unit VIe-20; Loamy range site (6 to 9 inches precipitation); wildlife site 3.*

Shano very fine sandy loam, 0 to 15 percent slopes, eroded (SnD2)-Except for the texture of the surface layer, this soil has a profile like that of Shano silt loam, 0 to 5 percent slopes. Included in mapping were small duned areas, mainly along field borders and in depressions. Also included were small areas of a Quincy loamy sand.

Blowouts are common in some of the areas. The hazard of further wind erosion is moderate.

This soil is used for production of dryland grain and for range. *Dryland capability unit IVe-21; Loamy range site (6 to 9 inches precipitation); wildlife site 1.*

Shano very fine sandy loam, 15 to 30 percent slopes, eroded (SnE2).-Except for the texture of the surface layer, this soil has a profile like that of Shano silt loam, 0 to 5 percent slopes. Much of the acreage consists of moderately steep areas incised by gullies that are difficult to cross with farm machinery. Included in mapping were a few areas where the slope is as much as 65 percent.

Runoff is generally slow to medium, but it is raid when the ground is frozen. The hazard of further erosion is moderate.

This soil is used for range. *Dryland capability unit VIe-20; Loamy range site (6 to 9 inches precipitation); wildlife site 3.*

Shano silt loam, 0 to 2 percent slopes (ShA).-This soil has a profile like that of Shano silt loam, 0 to 5 percent slopes. It is generally more than 60 inches deep, but a few areas 36 to 60 inches deep over bedrock were included.

This soil is well suited to both surface and sprinkler irrigation. Suitable crops include asparagus, sugar beets, hops, tree fruits, grapes, corn, mint, hay, and pasture. *Irrigated capability unit I-1; wildlife site 2.*

Shano silt loam, 2 to 5 percent slopes (ShB).-This soil has a profile like that of Shano silt loam, 0 to 5 percent slopes. It is more than 60 inches deep. Included in snapping were small areas of a Warden silt loam.

Runoff is slow. The hazard of water erosion is slight to moderate.

Suitable crops include asparagus, sugar beets, hops, tree fruits, grapes, hay, and pasture. *Irrigated capability unit IIe-2; wildlife site 2.*

Shano silt loam, 5 to 8 percent slopes (ShC).-This soil has a profile like that of Shano silt loam, 0 to 5 percent slopes. The depth to basalt bedrock is 60 inches or more. Included in mapping were small areas of a Warden silt loam and a Burke silt loam.

Runoff is medium. The hazard of water erosion is moderate.

Suitable crops include grapes, tree fruits, hay, and pasture. *Irrigated capability unit IIIe-2; wildlife site 2.*

Shano silt loam, 8 to 15 percent slopes (ShD).-This soil has a profile like that of Shano silt loam, 0 to 5 percent sloes. It is generally more than 60 inches deep. Included in mapping were small areas of Shano very fine sandy loam, deep, 2 to 8 percent slopes, eroded, areas of Warden silt loam, and a few areas that are 36 to 60 inches deep over bedrock.

Runoff is rapid. The hazard of water erosion is severe.

Tree fruits, hay, and pasture are well suited. *Irrigated capability unit IVe-2; wildlife site 4.*

Shano silt loam, deep, 2 to 5 percent slopes (SmB).-Basalt is at a depth of 36 to 60 inches in this soil, but the profile is otherwise like that of Shano silt loam, 0 to 5 percent slopes.

Runoff is slow. The Hazard of water erosion is slight to moderate.

Suitable crops include asparagus, hops, sugar beets, grapes, tree fruits, hay, and pasture. *Irrigated capability unit IIe-2; wildlife site 2.*

Shano silt loam, deep, 5 to 8 percent slopes (SmC).-Basalt is at a depth of 36 to 60 inches in this soil, but the profile is otherwise like that of Shano silt loam, 0 to 5 percent slopes.

Runoff is medium. The hazard of water erosion is moderate.

Suitable crops include tree fruits, grapes, hay, and pasture. *Irrigated capability unit IIIe-2; wildlife site 2.*

Shano very fine sandy loam, deep, 2 to 8 percent slopes, eroded (SoC2).-Except for the texture of the surface layer and depth to bedrock, this soil has a profile like that of Shano silt loam, 0 to 5 percent slopes. Basalt bedrock is at a depth of 36 to 60 inches.

Runoff is slow to medium. Water erosion is a slight to moderate hazard. Wind erosion is a moderate hazard when the surface is bare.

Tree fruits, hay, and pasture are suitable crops. *Irrigated capability unit IIIe-1; wildlife site 2.*

Starbuck Series

This series consists of well-drained, shallow, medium-textured soils on terraces. These soils formed under bunch grasses and sagebrush in silty wind-deposited material and in alluvium. They are nearly level to steep. Elevations range from 500 to 750 feet. The annual precipitation is 6 to 9 inches, the mean annual temperature is 50° F., and the frost-free season is about 155 days. Starbuck soils

are geographically associated with Prosser and Scooteney soils.

The surface layer is dark-brown silt loam about 3 inches thick. The subsoil is generally dark-brown silt loam that is underlain by dark-brown very gravelly silt loam. Basalt bedrock begins at a depth of 17 inches.

Unirrigated areas are used for range.

Starbuck silt loam, 0 to 8 percent slopes (SrBC).-This soil occurs on low terraces. In most places the slope is about 4 percent. Included in mapping were small areas of Burbank loamy fine sand, basalt substratum; areas of a Prosser silt loam; a few areas of Rock outcrop; and areas of Starbuck soils that have a slope of as much as 30 percent.

Permeability is moderate, and the water-holding capacity is low. Runoff is very slow to medium. The hazard of wind erosion is moderate, and the hazard of water erosion is slight. The effective rooting depth is 12 to 20 inches. Fertility is medium to low.

Profile in a grassy area, 120 feet west and 2,300 feet south of the intersection of Wilgus Road and U.S. Highway 12, NE1/4SE1/4 sec. 29, T. 9 N., R. 24 E. Profile is in an area mapped as Starbuck silt loam, 0 to 5 percent slopes, but is representative of this soil.

A-0 to 3 inches, dark-brown (10YR 3/3) silt loam, brown (10YR 5/3) when dry; weak, medium, platy structure breaking to weak, fine, granular; soft, friable, slightly sticky and slightly plastic; abundant roots; neutral (pH 7.0) ; abrupt, smooth boundary. 3 to 6 inches thick.

B-3 to 12 inches, dark-brown (10YR 3/3) silt loam, brown (10YR 5/ 3) when dry; weak, subangular blocky structure; soft, friable, slightly sticky and slightly plastic; plentiful roots; common fine pores; neutral (pH 7.3) ; gradual, wavy boundary. 3 to 17 inches thick.

IICca-12 to 17 inches, dark-brown (10YR 3/3) very gravelly silt loam, brown (10YR 5/3) when dry; slightly plastic; plentiful roots matted between rocks; mildly alkaline (pH 7.6) ; 70 percent gravel, mostly angular basalt; many of the pebbles are coated with lime-silica on the lower side; abrupt, wavy boundary. Variable thickness.

IIIR-17 inches, basalt bedrock with some fractures; some of the fractures are coated with lime-silica.

The A horizon ranges from dark brown (10YR 3/3) to dark grayish brown (10YR 4/2). In some places the IIC horizon contains rounded pebbles of granite, quartzite, and basalt in addition to the angular fragments of basalt. In some places the soil is entirely leached of free lime. Bedrock is at a depth of 12 to 20 inches. Outcrops of basalt are common.

This soil is used for range. *Dryland capability unit VIIs-20; Shallow range site (6 to 9 inches precipitation); wildlife site 3.*

Starbuck rocky silt loam, 5 to 45 percent slopes (SsE).-This soil has a profile like that of Starbuck silt loam, 0 to 8 percent slopes. About 20 to 50 percent of the acreage consists of Rock outcrop. Many of the outcrops occur as long escarpments. Included in mapping were a few areas where the slope is as much as 65 percent.

Runoff is medium to rapid, and the hazard of water erosion is moderate to severe.

This soil is used for range. *Dryland capability unit VIIs-20; Shallow range site (6 to 9 inches precipitation); wildlife site 5.*

Starbuck stony silt loam, 0 to 15 percent slopes (StD).-Except that the surface is stony, this soil has a profile like that of Starbuck silt loam, 0 to 8 percent slopes. In places about 5 percent of the acreage consists of Rock outcrop. The stones are mainly fragments of basalt bedrock.

This soil is used for range. A few areas are sprinkler irrigated and are used for pasture. *Dryland capability unit VIIs-20; Shallow range site (6 to 9 inches precipitation); wildlife site 5.*

Starbuck silt loam, 0 to 5 percent slopes (SrB).-This soil has a profile like that of Starbuck silt loam, 0 to 8 percent slopes. Included in mapping were small areas of a Scooteney silt loam, gravelly subsoil; a Prosser silt loam; a Wamba silt loam; and a few areas of Rock outcrop. Also included were a few areas that are strongly affected by salts and alkali. The hazard of water erosion is slight to moderate.

Most areas are used for hay and pasture, but some are used for mint, corn, wheat, and other shallow, rooted crops. *Irrigated capability unit IVe-4; wildlife site 4.*

Starbuck silt loam, 5 to 8 percent slopes (SrC).-This soil has a profile like that of Starbuck silt loam, 0 to 8 percent slopes. Included in mapping were small areas of a Prosser silt loam; a Scooteney silt loam, gravelly subsoil and Rock outcrop. Runoff is medium, and the hazard of water erosion is moderate.

This soil is used mainly for pasture. *Irrigated capability unit IVe-2; wildlife site 4.*

Umapine Series

This series consists of moderately well drained, medium-textured, saline-alkali soils on bottom lands. These soils are nearly level. They formed in alluvium under a vegetative cover of wildrye, alkali bluegrass, and greasewood. Elevations range from 250 to 1,000 feet. The annual precipitation is 6 to 9 inches, the mean annual temperature is 50° F., and the frost-free season is about 150 days. These soils are geographically associated with Esquatzel and Warden soils.

In a representative profile the surface layer is dark-brown to dark grayish-brown silt loam about 8 inches thick. Below this is dark grayish-brown, stratified silt loam to a depth of 60 inches or more.

Undrained and unirrigated areas are used for range. In places the soils have been drained and partially reclaimed.

Umapine silt loam, 0 to 5 percent slopes (UmB).-This is a saline-alkali soil on alluvial bottom lands. In most places the slope is about 1 percent. Included in mapping were small areas where the soil contains a weakly cemented hardpan. Also included were a few small areas where the surface layer is fine sandy loam. The sandy areas are hummocky and highly susceptible to wind erosion.

This soil is moderately well drained and moderately permeable. Runoff is very slow, and the hazard of both wind and water erosion is slight. The effective rooting depth is about 30 inches, and fertility is low to medium. The water table is seasonally high. Drainage and irrigation increase the rooting depth and improve fertility.

Representative profile in a cultivated area, 1 mile east of county line and 300 feet north of Highway 14, SW1/4SW1/4 sec. 32, T. 5 N., R. 24 E.

Ap1-0 to 3 inches, dark-brown (10YR 4/3) silt loam, pale brown (10YR 6/3) when dry; weak, thin, platy structure; slightly hard, friable, slightly sticky and plastic; abundant

roots; very strongly alkaline (pH 9.4); violent effervescence; abrupt, smooth boundary. 2 to 3 inches thick.

Ap2-3 to 8 inches, dark grayish-brown (10YR 4/2) silt loam, pale brown (10YR 6/3) when dry; common faint mottles; moderate, thick, platy structure; hard, friable, slightly sticky and plastic; plentiful roots; common fine pores; very strongly alkaline (pH 9.2) ; violent effervescence; abrupt, smooth boundary. 4 to 6 inches thick.

C1ca-8 to 16 inches, dark grayish-brown (10YR 4/2) silt loam, light brownish gray (10YR 6/2) when dry; common faint mottles; massive; hard, friable, slightly sticky and plastic: plentiful roots; common fine pores; strongly alkaline (pH 8.9); violent effervescence; gradual, wavy boundary. 7 to 10 inches thick.

C2ca-16 to 44 inches, dark grayish-brown (10YR 4/2) light silt loam, light brownish gray (10YR 6/2) when dry; common faint mottles; massive; slightly hard, friable, slightly sticky and slightly plastic; plentiful roots to a depth of 24 inches and few below; common fine pores; strongly alkaline (pH 8.6) ; violent effervescence; gradual, wavy boundary. Variable thickness.

C3-44 to 52 inches, dark grayish-brown (10YR 4/2) very fine sandy loam, light brownish gray (10YR 6/2) when dry; common faint mottles; massive; soft, friable, nonsticky and slightly plastic; few roots; common fine pores; strongly alkaline (pH 8.9); violent effervescence; gradual, wavy boundary. Variable thickness.

C4-52 to 60 inches, dark grayish-brown (10YR 4/2) silt loam, light brownish gray (10YR 6/2) when dry; water table at a depth of 52 inches; common faint mottles; massive; slightly hard, friable, slightly sticky and plastic; strongly alkaline (pH 9.0); violent effervescence.

The A horizon ranges from dark brown (10YR 4/3) to dark grayish brown (10YR 4/2) in color and from fine sandy loam to silt loam in texture. Reaction ranges from strongly alkaline to very strongly alkaline. The material underlying the A horizon is mainly silt loam, but in places it is stratified with sandy loam and lenses of sand arid gravel. Reaction ranges from mildly alkaline to strongly alkaline below a depth of 8 inches.

This soil is used for range. *Dryland capability unit VIs-22; Alkali range site; wildlife site 3.*

Umapine silt loam, drained, 0 to 2 percent slopes (UpA).-This soil has a profile like that of Umapine silt loam, 0 to 5 percent slopes. It has been drained, and the surface layer has been somewhat leached of salts.

The surface layer is moderately to strongly alkaline. The effective rooting depth is more than 36 inches. Fertility is medium. Runoff is very slow.

Suitable crops include alfalfa, asparagus, and sugar beets. *Irrigated capability unit IIs-1; wildlife site 4.*

Walla Walla Series

This series consists of deep, well-drained, medium-textured soils on high uplands in the Rattlesnake Hills. These soils developed under bunch grasses in silty windblown deposits. They are gently sloping to steep. Elevations range from 2,200 to 3,500 feet. The annual precipitation is 11 to 15 inches, the mean annual temperature is 47° F., and the frost-free season is about 130 days. Walla Walla soils are geographically associated with Lickskillet soils.

The surface layer is very dark brown silt loam about 11 inches thick. The subsoil is very dark grayish-brown to grayish-brown silt loam to a depth of about 48 inches. The substratum is grayish-brown to brown silt loam. The soil below a depth of about 36 inches is calcareous.

Walla Walla soils are used mainly for wheat in a crop-fallow system.

Walla Walla silt loam, 0 to 5 percent slopes (WaB).-This soil occurs on uplands in the Rattlesnake Hills. In most places the. slope is about 4 percent. Included in mapping were small areas of an Endicott silt loam.

This soil is well drained and moderately permeable. The water-holding capacity is high. Surface runoff is generally very slow to slow, and the hazard of wind and water erosion is slight. On long slopes, however, and during periods when the soil is frozen, runoff is more rapid, and water erosion is a hazard. The effective rooting depth is more than 36 inches. Fertility is high.

Representative profile in a cultivated area, 125 feet south of Bennett Road and 1,500 feet east of Jones Road, NEl/4NW1/4 sec. 25, T. 11 N., R. 24 E.

Ap-0 to 5 inches, very dark brown (10YR 2/2) silt loam, dark grayish brown (10YR 4/2) when dry; medium, fine, subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; abundant roots; neutral (pH 6.8) ; abrupt, smooth boundary. 4 to 6 inches thick.

A1-5 to 11 inches, very dark brown (10YR 2/2) silt loam, grayish brown (10YR 5/2) when dry; weak, coarse, prismatic structure and weak, thick, platy; slightly hard, friable, slightly sticky and slightly plastic; plentiful roots; common fine pores; neutral (pH 6.8); gradual, wavy boundary. 3 to 10 inches thick.

B1-11 to 22 inches, very dark grayish-brown (10YR 3/2) silt loam, brown (10YR 5/3) when dry; weak, coarse, prismatic structure; slightly hard, friable, slightly sticky and slightly plastic; plentiful roots; common fine pores; neutral (pH 7.0); gradual, wavy boundary. 10 to 20 inches thick.

B21-22 to 36 inches, dark grayish-brown (10YR 4/2) silt loam, brown (10YR 5/3) when dry; moderate, medium, prismatic structure; few thin coatings on ped surfaces; slightly hard, friable, slightly sticky and slightly plastic; plentiful roots; common fine pores; neutral (pH 7.3) ; abrupt, wavy boundary. 10 to 15 inches thick.

B22ca-36 to 48 inches, grayish-brown (2.5Y 5/2) silt loam, pale brown (10YR 6/3) when dry; moderate, medium, prismatic structure; few thin coatings on ped surfaces; hard, friable, sticky and plastic; few roots; common fine pores; disseminated and segregated mycelial lime; violent effervescence; strongly alkaline (pH 8.8); abrupt, wavy boundary. 8 to 20 inches thick.

C1ca-48 to 61 inches, grayish-brown (2.5Y 5/2) silt loam, pale brown (10YR 6/3) when dry; massive; slightly hard, friable, slightly sticky and slightly plastic; few roots; few fine pores; violent effervescence; strongly alkaline (pH 8.8) ; diffuse, wavy boundary. 8 to 25 inches thick.

C2ca-61 to 73 inches, brown (10YR 5/3) silt loam, pale brown (10YR 6/3) when dry; massive; slightly hard, friable, slightly sticky and slightly plastic; few roots; few fine pores; violent effervescence; strongly alkaline (pH 8.6) ; abrupt, wavy boundary. 0 to many feet thick.

IIR-73 inches, basalt bedrock, generally capped by a lime-silica coating or by a cemented hardpan.

The A horizon ranges from very dark brown (10YR 2/2) to very dark grayish brown (10YR 3/2) in color and from 8 to 16 inches in thickness. Segregated mycelial lime does not occur in the B horizon in all profiles. Basalt bedrock is at a depth of 36 to 60 inches in places.

Most of the acreage is cultivated. Wheat and barley are grown in a crop-fallow system. *Dryland capability unit IIc-20; Loamy range site (9 to 15 inches precipitation); wildlife site 6.*

Walla Walla silt loam, 5 to 15 percent slopes (WaD).-The profile of this soil is like that of Walla Walla silt loam, 0 to 5 percent slopes. In some places about 25 to 50 percent of the surface layer has been lost through erosion.

Runoff is slow to medium, and the hazard of water erosion is slight to moderate.

About 70 percent of the acreage is used for wheat and barley, and the rest for range. *Dryland capability unit IIIe-20; Loamy range site (9 to 15 inches precipitation); wildlife site 6.*

Walla Walla silt loam, 30 to 65 percent slopes (WaF).-The profile of this soil is like that of Walla Walla silt loam, 0 to 5 percent slopes. In places more than 50 percent of the surface layer has been lost through erosion. Free lime occurs below a depth of 60 inches on some of the north-facing slopes. Included in snapping were small areas of a Lickskillet very stony silt loam.

Runoff .is rapid to very rapid. The hazard of water erosion is severe to very severe.

This soil is used for range. *Dryland capability unit VIe-21; Loamy range site (9 to 15 inches precipitation); wildlife site 8.*

Walla Walla silt loam, 15 to 30 percent slopes, severely eroded (WaE3).-This soil has a profile like that of Walla Walla silt loam, 0 to 5 percent slopes. In places erosion has removed all of the surface layer. Free lime occurs below a depth of 60 inches on some of the north-facing slopes.

Runoff' is medium to rapid, and the hazard of water erosion is severe. Eroded shallow gullies leading to deep gullies or intermittent streams are common.

Most of the acreage is used for range and wildlife habitat. About 20 percent is used for wheat and barley. *Dryland capability unit IVe-20; Loamy range site (9 to 15 inches precipitation); wildlife site 8.*

Wamba Series

This series consists of somewhat poorly drained, medium-textured soils on terraces. These soils occur as nearly level to slightly depressed areas. They formed in sandy and gravelly alluvium mantled with a mixture of alluvium and silty, windblown deposits. Elevations range from 675 to 775 feet. The annual precipitation is 6 to 8 inches, the mean annual temperature is 50° F., and the frost-free season is about 150 days. Wamba soils are geographically associated with Scooteney and Starbuck soils.

The surface layer is very dark brown silt loam about 5 inches thick. The subsoil is mainly dark-gray, mottled silt loam that grades to gravelly silt loam at a depth of about 17 inches. Sand and gravel begins at a depth of about 23 inches and extends to a depth of 60 inches or more.

These soils are used mainly for hay and pasture.

Wamba silt loam, 0 to 2 percent slopes (WbA).-This soil occurs on old alluvial terraces. In most places the slope is about 1 percent. Included in mapping were small areas where the surface layer is strongly affected by salts and alkali. The vegetation in these areas consists mainly of saltgrass. Also included were small areas of Starbuck silt loam and Scooteney silt loam.

This soil is somewhat poorly drained. Permeability is moderate, and the water-holding capacity is moderate to moderately high. Runoff is very slow to ponded. Drainage is restricted, mainly by slight cementation of rocks or by basalt dikes. The water table is seasonally high. There is little or no hazard of erosion. The effective rooting depth is about 30 inches. Fertility is medium.

Representative profile in a cultivated area, 75 feet north of Johnson Road and 1,200 feet west of Missimer Road, SW1/4SE1/4SE1/4 sec. 28, T. 9 1T., R. 24 E.

Ap-0 to 5 inches, very dark brown (10YR 2/2) silt loam, grayish brown (10YR 5/2) when dry; medium, fine, granular structure; slightly hard, friable, nonsticky and slightly plastic; abundant roots; moderately alkaline (pH 8.0) ; slight effervescence; abrupt, smooth boundary. 3 to 6 inches thick.

B21g-5 to 9 inches, very dark gray (10YR 3/1) silt loam, gray (10YR 5/1) when dry; common medium mottles, reddish brown (5YR 4/4). and strong brown (7.5YR 5/6) when dry; weak, medium, subangular blocky structure; hard, firm, nonsticky and slightly plastic; plentiful roots; common fine pores; mildly alkaline (pH 7.6) ; clear, wavy boundary. 2 to 5 inches thick.

B22g-9 to 17 inches, dark-gray (10YR 4/1) silt loam, gray (10YR 6/1) when dry; common medium mottles, dark brown (10YR 4/3) and brownish yellow (10YR 6/6) when dry; weak, medium, subangular blocky structure; hard, friable, slightly sticky and plastic; plentiful roots; common fine pores; mildly alkaline (pH 7.8) ; gradual, wavy boundary. 5 to 12 inches thick.

IIC1g-17 to 23 inches, dark-gray (10YR 4/1) gravelly silt loam, gray (10YR 6/1) when dry; common medium mottles, dark brown (10YR 4/3) and brownish yellow (10YR 6/6) when dry; massive; slightly hard, friable, slightly sticky and plastic; plentiful roots; common fine pores; mildly alkaline (pH 7.8); gradual, wavy boundary. 5 to 15 inches thick.

IIIC2-23 to 60 inches, sand and gravel; single grain; loose, nonsticky and nonplastic ; plentiful roots; moderately alkaline (pH 8.0) ; 60 percent pebbles more than 1 inch in diameter; some of the pebbles are coated with lime-silica on the lower side.

Reaction in the Ap horizon ranges from 7.5 to 8.4. When crushed, the B and C horizons have a color one unit higher in chroma because of the mixing of matrix material with the mottled material. The depth to sand and gravel ranges from 20 to 40 inches. In areas that occur in close association with Starbuck soils, this Wamba soil is generally underlain by basalt bedrock, rather than by sand and gravel.

This soil is used mainly for pasture. Drained and irrigated areas are used for corn, peas, mint, and hay. *Irrigated capability unit IIIw-1; wildlife site 4.*

Warden Series

This series consists of well-drained, medium-textured soils on uplands in the Rattlesnake Hills and at the lower elevations in Horse Heaven Hills. These soils developed under bunch grasses in a mantle of windblown deposits over reworked lacustrine material. They are gently sloping to steep. Elevations range from 550 to 1,000 feet. The annual precipitation is 6 to 9 inches, the mean annual temperature is 50° F., and the frost-free season is about 150 days. These soils are geographically associated with Shano and Scooteney soils.

The surface layer is dark-brown to dark grayish-brown silt loam or very fine sandy loam about 9 inches thick. The subsoil is dark grayish-brown silt loam that grades to grayish-brown, strongly calcareous silt loam at a depth of about 19 inches. The substratum is brown to grayish-brown silt loam extending to a depth of 60 inches or more.

Unirrigated areas of these soils are used for small grain in a crop-fallow system and for range. Irrigated areas are used for asparagus, sugar beets, hops, tree fruits, grapes, corn, mint, hay, and pasture.

Warden silt loam, 0 to 5 percent slopes (WdAB).-This soil occurs on uplands. In most places the slope is about 4 percent. Included in mapping were areas where the slope is as much as 15 percent. Also included were small areas of Shano silt loam; of Warden very fine sandy loam, eroded; and of Prosser silt loam.

Drainage is good. Permeability is moderate, and the water-holding capacity is high. Runoff is very slow to slow. The hazard of water erosion is slight, and the hazard of wind erosion is slight to moderate. Tilth is good, and fertility is high. The thickness of the rooting zone is 40 to more than 60 inches.

Profile in a cultivated area, 600 feet southeast of the intersection of Hanks and McDonald Roads, NW1/4NW1/4 sec. 17, T. 9 N., R. 25 E. Profile is .in an area mapped as Warden silt loam, 2 to 5 percent slopes, but is representative of this soil.

Ap1-0 to 6 inches, dark grayish-brown (10YR 4/2) silt loam, grayish brown (10YR 5/2) when dry; weak, fine, granular structure; soft, friable, nonsticky and slightly plastic; abundant roots; neutral (pH 6.8) ; abrupt, smooth boundary. 4 to 6 inches thick.

Ap2-6 to 9 inches, dark grayish-brown (10YR 4/2) silt loam, light brownish gray (10YR 6/2) when dry; moderate, medium, subangular blocky structure; slightly hard, friable, nonsticky and slightly plastic; plentiful roots; common fine tubular pores; neutral (pH 7.2) ; clear, smooth boundary. 0 to 3 inches thick.

B2-9 to 19 inches, dark grayish-brown (10YR 4/2) silt loam, light brownish gray (10YR 6/2) when dry; weak, medium, subangular blocky structure; soft, friable, slightly sticky and slightly plastic; plentiful roots; common fine tubular pores; mildly alkaline (pH 7.6); abrupt, wavy boundary. 10 to 20 inches thick.

IIC1ca-19 to 29 inches, grayish-brown (2.5Y 5/2) silt loam, light brownish gray (2.5Y 6/2) when dry; massive; slightly hard, friable, slightly sticky and slightly plastic; plentiful roots; common fine tubular pores; violent effervescence; moderately alkaline (pH 8.4) ; gradual, wavy boundary. 8 to 15 inches thick.

IIC2ca-29 to 51 inches, brown (10YR 5/3) silt loam, pale brown (10YR 6/3) when dry; finely laminated; slightly hard, friable, slightly sticky and slightly plastic; plentiful roots; common fine tubular pores; disseminated and segregated mycelial lime; violent effervescence; moderately alkaline (pH 8.4); gradual, wavy boundary. Variable thickness.

IIC3ca-51 to 60 inches, grayish-brown (2.5Y 5/2) silt loam, light brownish gray (2.5Y 6/2) when dry; massive; slightly hard, friable, slightly sticky and slightly plastic; disseminated and segregated mycelial lime; violent effervescence; moderately alkaline (pH 8.4).

The A horizon ranges from dark grayish brown (10YR 4/2) to dark brown (10YR 4/3) in color and from fine sandy loam to silt loam in texture. It is 4 to 9 inches thick. The B horizon ranges from dark grayish brown (10YR 4/2) to dark brown (l0YR 4/3) in color. The C horizon ranges from 10YR to 2.5Y in hue. In places this horizon is stratified with sandy loam or loamy sand. In many places it is dissected by laminated, vertical or diagonal, clastic dikes. The depth to the calcareous layer is commonly about 20 inches, but it ranges from 15 to 30 inches. The depth to bedrock is more than 60 inches in most places, but it is about 40 inches in some areas. In places granite boulders are common.

Most of the acreage is cultivated. Wheat, barley, and rye are grown in a crop-fallow system. *Dryland capability unit IVc-20; Loamy range site (9 to 15 inches precipitation); wildlife site 1.*

Warden silt loam, 15 to 30 percent slopes, severely eroded (WdE3).-This soil has a profile like that of Warden silt loam, 0 to 5 percent slopes. In places erosion has removed all of the surface layer. Much of the acreage consists of narrow, elongated areas (fig. 13) incised by shallow and deep gullies, which are difficult to cross with farm machinery. Included in snapping were small areas of Kiona very stony silt loam and Quincy loamy sand.

Figure 13.-An area of Warden silt loam, 15 to 30 percent slopes, severely eroded. This soil typically occurs as narrow, elongated areas.

Runoff is normally slow to medium, but it is rapid during occasional heavy downpours and after rapid snowmelt. The hazard of further water erosion is moderate to severe.

Most of the acreage is used for grazing, but wheat is grown in a crop-fallow system in a few areas. *Dryland capability unit VIe-20; Loamy range site (6 to 9 inches precipitation); wildlife site 3.*

Warden silt loam, 30 to 65 percent slopes (WdF).-This soil has a profile like that of Warden silt loam, 0 to 5 percent slopes. Included in mapping were small severely eroded areas and small areas of Kiona very stony silt loam, 30 to 65 percent slopes.

Runoff is rapid to very rapid, and the hazard of water erosion is severe to very severe.

This soil is used for range. *Dryland capability unit VIIe-21; Loamy range site (6 to 9 inches precipitation); wildlife site 3.*

Warden very fine sandy loam, 0 to 15 percent slopes, eroded (WfC2).-Except for the texture of the surface layer, this soil has a profile like that of Warden silt loam, 0 to 5 percent slopes. Included in mapping were small areas of Hezel loamy fine sand, 0 to 30 percent slopes, and of Quincy loamy sand, 0 to 30 percent slopes.

The hazard of further wind erosion is moderate. Blowouts are common in places.

This soil is used mainly for range, but some areas are cultivated in a crop-fallow system. *Dryland capability unit IVe-21; Loamy range site (6 to 9 inches precipitation); wildlife site 3.*

Warden very fine sandy loam, 15 to 30 percent slopes, eroded (WfE2).-Except for the texture of the surface layer, this soil has a profile like that of Warden silt loam, 0 to 5 percent slopes. Much of the acreage is incised by intermittent streams. These areas are difficult to cross with farm machinery. Included in mapping were a few areas where the slope is as much as 40 percent. Also included were small areas of Quincy loamy sand, 0 to 30 percent slopes.

Runoff is normally slow to medium, but it is rapid during occasional heavy downpours and after rapid snowmelt, especially if the ground is frozen. The hazard of further erosion is moderate.

This soil is used for range. *Dryland capability unit VIe-20; Loamy range site (6 to 9 inches precipitation); wildlife site 3.*

Warden silt loam, 0 to 2 percent slopes. (WdA).-This soil has a profile like that of Warden silt loam, 0 to 5 percent slopes. It is generally more than 60 inches deep. Included in mapping were small areas of Shano silt loam, 0 to 2 percent slopes, and a few areas that are strongly affected by salts and alkali.

Suitable crops include asparagus, sugar beets, hops, tree fruits, grapes, corn, mint, hay, and pasture. *Irrigated capability unit, I-1; wildlife site 2.*

Warden silt loam, 2 to 5 percent slopes (WdB).-This soil has a profile like that of Warden silt loam, 0 to 5 percent slopes. Included in mapping were small areas of Shano silt loam, 2 to 5 percent slopes, and Prosser silt loam, 2 to 5 percent slopes.

Runoff is slow. The hazard of water erosion is slight to moderate. To minimize the erosion hazard, irrigation furrows and corrugations should be held to a gradient of 2 percent, or else the runs should be short.

Suitable crops include asparagus, sugar beets, hops, tree fruits, grapes, corn, mint, hay, and pasture. *Irrigated capability unit IIe-2; wildlife site 2.*

Warden silt loam, 5 to 8 percent slopes (WdC).-This soil has a profile like that of Warden silt loam, 0 to 5 percent slopes. Included in mapping were small areas of Shano silt loam, 5 to 8 percent slopes, and Prosser silt loam, 5 to 15 percent slopes. Also included were a few areas that are strongly affected by salts and alkali.

Runoff is medium. The hazard of water erosion is moderate.

Suitable crops include tree fruits, grapes, hay, and pasture. *Irrigated capability unit IIIe-2; wildlife site 2.*

Warden silt loam, 8 to 15 percent slopes (WdD).-This soil has a profile like that of Warden silt loam, 0 to 5 percent slopes. Included in mapping were small areas of Warden very fine sandy loam, 8 to 15 percent slopes, eroded, and Shano silt loam, 8 to 15 percent slopes.

Runoff is rapid, and the hazard of water erosion is severe. In some places wind erosion is a moderate hazard.

Tree fruits, hay, and pasture are suitable crops. *Irrigated capability unit IVe-2; wildlife site 4.*

Warden very fine sandy loam, 0 to 2 percent slopes, eroded (WfA2).-Except for the texture of the surface layer, this soil has a profile like that of Warden silt loam, 0 to 5 percent slopes. The coarser texture results from wind erosion, which has blown out fine particles from the surface layer. Included in mapping were small areas of Hezel loamy fine sand, 0 to 2 percent slopes.

Runoff is very slow. The hazard of further wind erosion is moderate when the surface is bare. The water-holding capacity is high.

Tree fruits, grapes, hay, and pasture are suitable crops. *Irrigated capability unit IIe-1; wildlife site 2.*

Warden very fine sandy loam, 2 to 8 percent slopes, eroded (WfB2).-Except for the texture of the surface layer, this soil has a profile like that of Warden silt loam, 0 to 5 percent slopes. Included in mapping were small areas of Hezel loamy fine sand, 2 to 15 percent slopes.

Runoff is slow to medium, and the hazard of water erosion is slight to moderate. The hazard of further wind erosion is moderate when the surface is bare.

Suitable crops include tree fruits, grapes, hay, and pasture. *Irrigated capability unit IIIe-1; wildlife site 2.*

Warden very fine sandy loam, 8 to 15 percent slopes, eroded (WfD2).-Except for the texture of the surface layer, this soil has a profile like that of Warden silt loam, 0 to 5 percent slopes. Included in mapping were small areas of Hezel loamy fine sand, 2 to 15 percent slopes.

Runoff is medium to rapid, and the hazard of water erosion is severe. The hazard of further wind erosion is moderate when the surface is bare.

Suitable crops include tree fruits, grapes, hay, and pasture. *Irrigated capability unit IVe-1; wildlife site 4.*

Willis Series

This series consists of well-drained, shallow and moderately deep, medium-textured soils on uplands in the Rattlesnake Hills and in the Horse Heaven Hills. These soils developed under bunch grasses in silty, wind-deposited material. They are underlain by a lime-silica hardpan overlying basalt bedrock. The slopes are gentle to steep. Elevations range from 1,200 to 2,200 feet. The annual precipitation is 8 to 12 inches, the mean annual temperature is 48° F., and the frost-free season is about 140 days. Willis soils are geographically associated with Ritzville soils.

The surface layer is very dark grayish-brown silt loam 3 to 8 inches thick. The subsoil is dark-brown silt loam that grades to dark grayish-brown, strongly calcareous silt loam. An indurated lime-silica hardpan occurs at a depth of 15 to 36 inches.

These soils are used for range and for wheat in a crop-fallow system.

Willis silt loam, shallow, 0 to 15 percent slopes (WtD).-This soil occurs mainly on broad ridgetops in the Rattlesnake Hills. In most places the slope is about 4 percent. The depth to the hardpan is generally less than 20 inches, but included in mapping were small areas where the hardpan is at a depth of 20 to 36 inches. Also included were small areas of very fine sandy loam and areas of Rock outcrop.

Drainage is good. Permeability is moderate, and the water-holding capacity is low. Runoff is very slow to slow. The hazard of wind and water erosion is slight to moderate. The effective rooting depth is less than 20 inches. Fertility is low to medium.

Representative profile in an area of native grasses, 50 feet west of Jones Road and 1 1/4 miles north of Anderson Road, SE1/4SE1/4 sec. 16, T. 10 N., R. 24 E.

A-0 to 3 inches, very dark grayish-brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) when dry; weak, fine, granular structure and weak, thin, platy; soft, friable, nonsticky and slightly plastic; abundant roots; neutral (pH 7.0) ; abrupt, wavy boundary. 3 to 8 inches thick.

B-3 to 10 inches, dark-brown (10YR 3/3) silt loam, brown (10YR 5/3) when dry; weak, coarse, prismatic structure; slightly hard, friable, slightly sticky and slightly plastic; plentiful roots; common fine pores; mildly alkaline (pH 7.6); abrupt, wavy boundary. 5 to 20 inches thick.

C1ca-10 to 18 inches, dark grayish-brown (10YR 4/2) silt loam, light brownish gray (10YR 6/2) when dry; massive; soft, friable, slightly sticky and slightly plastic; plentiful roots; few fine pores; violent effervescence; moderately alkaline (pH 8.3); abrupt, wavy boundary. 3 to 12 inches thick.

IIC2casim-18 inches, indurated, lime-silica cemented hardpan, underlain by basalt bedrock.

The B horizon is less distinct in areas where the hardpan is closer to the surface. In places small fragments of the hardpan are scattered throughout the profile. The hardpan is generally underlain by basalt bedrock, but in places it is underlain by gravel.

This soil is used mainly for range. *Dryland capability unit VI-20; Shallow range site (9 to 15 inches precipitation); wildlife site 7.*

Willis silt loam, 0 to 5 percent slopes (WsB).-This soil is moderately deep, but the profile is otherwise like that of Willis silt loam, shallow, 0 to 15 percent slopes.

The water-holding capacity is moderate to moderately high. The effective rooting depth is 20 to 36 inches. Fertility is medium to high.

This soil is used mainly for wheat in a crop-fallow system. *Dryland capability unit IIIs-20; Loamy range site (9 to 15 inches precipitation); wildlife site 7.*

Willis silt loam, 30 to 65 percent slopes (WsF).-Except for the slope and the depth, this soil is similar to Willis silt loam, shallow, 0 to 15 percent slopes. Included in mapping were small areas of a Ritzville silt loam and of a Willis silt loam, severely eroded, and small rocky or shallow areas.

The water-holding capacity is moderate to moderately high. The effective rooting depth is 20 to 36 inches. Fertility is medium to high. Runoff is rapid, and the hazard of erosion is very severe.

This soil is used for grazing. *Dryland capability unit VIIe-21; Loamy range site (9 to 15 inches precipitation); wildlife site 7.*

Willis silt loam, 15 to 30 percent slopes, severely eroded (WsE3).-In places this soil has lost all of the surface layer through erosion, but the profile is otherwise like that of Willis silt loam, shallow, 0 to 15 percent slopes. Much of the acreage consists of narrow, elongated areas incised by gullies that are not easy to cross with farm machinery. Included in mapping were small areas of Ritzville silt loam, severely eroded, and small rocky or shallow areas.

Runoff is normally slow to medium, but it is rapid during occasional heavy downpours and after rapid snowmelt. The hazard of further water erosion is moderate to severe.

Most of the acreage is used for grazing, but wheat is grown in a crop-fallow system in a few areas. *Dryland capability unit VIe-20; Shallow range site (9 to 15 inches precipitation), wildlife site 7.*

Formation and Classification of the Soils

This section tells how soil-forming factors have affected formation of the soils of the Benton County Area. It shows the classification of the soils according to both the system used before 1965 and the current system and describes each of the great soil groups represented in the Area.

Factors of Soil Formation

Soils differ in fertility, physical and chemical properties, and productivity because they are the product of the interaction of several soil-forming factors. These factors are: (1) the physical and mineralogical composition of the parent material; (2) the climate under which the soil material accumulated and has existed since accumulation; (3) relief, or lay of the land; (4) the vegetation; and (5) the length of time these forces have been active. The soil-forming factors, as they affect the soils of the Benton County Area, are described in the following paragraphs.

Parent material

The soils of this Area formed in five distinct kinds of parent material of mixed mineralogy: recent alluvium, old alluvium (basically glacial outwash), eolian sands, lacustrine deposits, and loess. Basalt bedrock underlies all these deposits. The basalt is of multiple flows and undetermined thickness; in the Rattlesnake Hills, oil drills have reached a depth of twelve thousand feet without clearing basalt.

In places the soils are underlain by a hardpan cemented with lime or lime and silica. The origin of the hardpan is unknown. The pan generally appears to be unrelated to the present-day soils. One theory is that the pan formed along the edges of old lakes before deposition of the material in which the present-day soils formed. Another is that the pan resulted from soil-forming processes acting on soil material that was subsequently eroded away. The hardpan has been thickened in places by the addition of lime and silica from present-day soil material. In the drier parts of the Area, parent material has had more influence on soil formation than other factors.

Soils that formed in lacustrine deposits are particularly interesting in this Area, where loessal soils are so extensive. The lacustrine sediments are part of the Touchet Beds. Soils of the Warden series formed in this material. Their subsoil consists of weakly stratified sediments that have been reworked to the extent that they are discontinuous.

In many places the sediments are dissected by vertical and diagonal elastic dikes (fig. 14). The dikes apparently formed when wet sediments, under pressure from below, were forced upward through cracks in the drier sediments near the surface or when material was deposited in cracks from above.

Another peculiarity of the soils that formed in lacustrine deposits is that ice-transported granite boulders occur sporadically (fig. 15).

Climate

This Area lies within the rain shadow of the Cascade Mountains. The annual precipitation ranges from approximately 6 inches at a 500-foot elevation to approximately 15 inches at an elevation of 3,500 feet. At the Prosser Irrigation Experiment Station, elevation 840 feet, the average annual precipitation is 7.51 inches, and the average total evaporation from April to October, inclusive, is 36.93 inches (14).

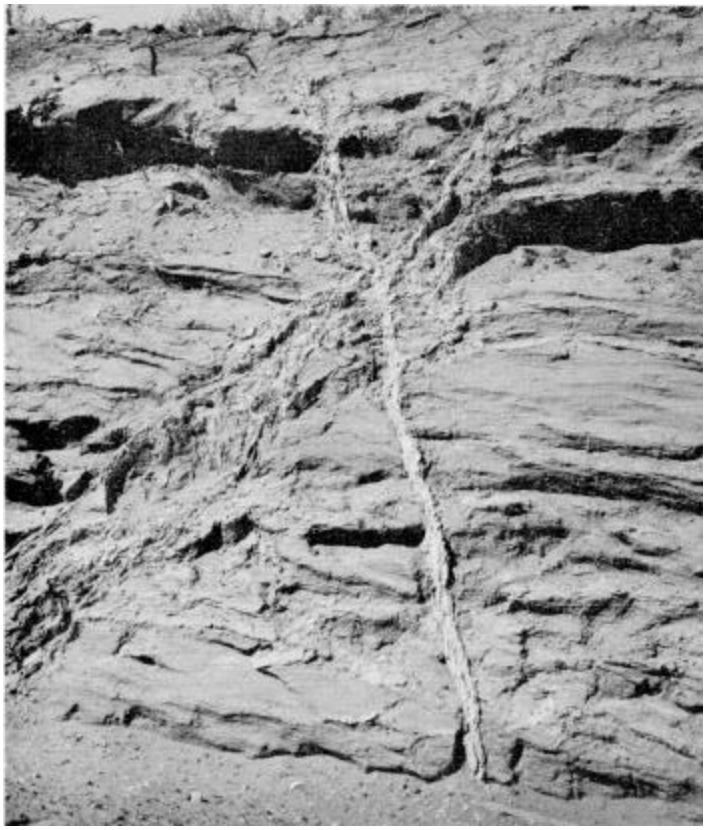


Figure 14.-Vertical elastic dike in an area of Warden silt loam. This kind of dike is common in soils derived from Touchet sediments.

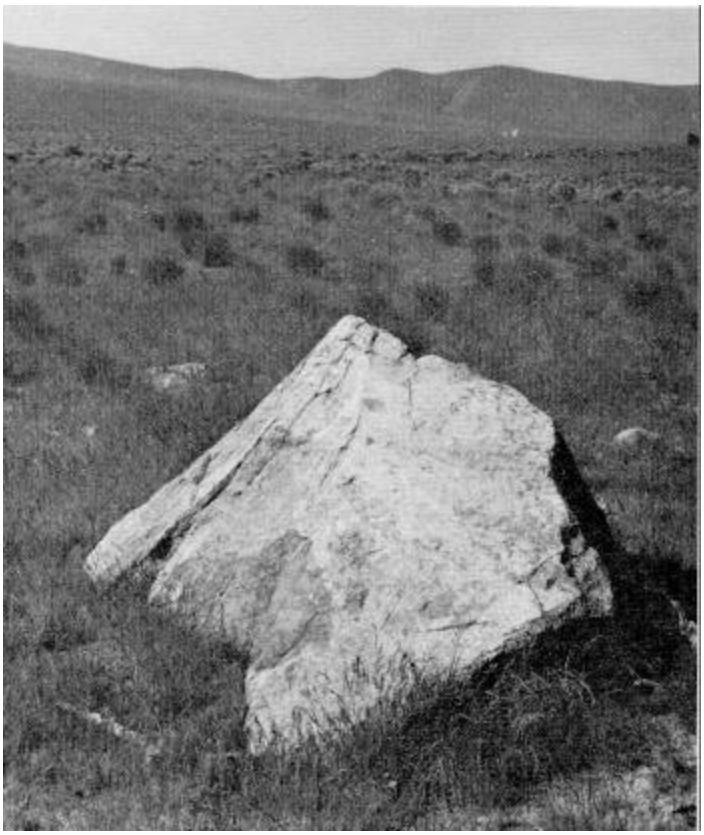


Figure 15.-Granite boulder in an area of Warden silt loam. This boulder was ice-rafted from a distant area and deposited in its present position when the ice melted.

Precipitation generally takes the form of gentle showers, which cause only a minimum of water erosion, or of light snow during the dormant season. The moisture effectively penetrates the soil, but the amount is so small that soluble salts are leached to depths of generally less than 40 inches. The effectiveness of chemical and biological activity associated with soil weathering is limited because of the low temperatures that prevail in winter.

The light precipitation rarely saturates the soils, and consequently, with few exceptions, the amount of clay and other particles moved downward has been insufficient to form a strong B horizon. Where precipitation is heavier, a few thin clay films occur on ped surfaces in the subsoil.

Relief

Relief affects soil formation mainly through its effect on drainage, runoff, and normal and accelerated erosion.

The relief in this Area is characterized by two major uplifts, the Rattlesnake Hills and Horse Heaven Hills. These two areas have steep, broken, northern exposures. Southern exposures are common. They are long and gentle and are dissected into large areas by drainageways. Elevations range from 3,600 feet in the Rattlesnake Hills to 250 feet in the southern part of the Area, along the Columbia River. Generally, the higher the elevation, the greater the amount of precipitation (fig. 16).

Vegetation

Vegetation affects soil formation mainly by supplying organic matter. The amount of organic matter in the soil affects water-holding capacity, infiltration, fertility, and tilth. A soil that has a good supply of organic matter generally supports a good stand of vegetation that protects it against wind and water erosion.

In this Area the organic-matter content varies, and this variation is reflected in the color of the soil. Where annual precipitation amounts to 6 to 9 inches, the organic-matter content of the surface soil is generally less than 1 percent and the soil is dark grayish brown when moist. Where annual precipitation amounts to 9 to 12 inches, the organic-matter content of the surface soil is 1 to 2 percent and the soil is generally very dark grayish brown when moist. Where annual precipitation amounts to 12 to 15 inches, the organic-matter content of the surface soil is about 3 percent and the soil is very dark brown when moist.

Under the prevailing climate, the predominant vegetation on the soils that have a medium-textured surface layer is bluebunch wheatgrass. The vegetation is more varied on the droughty, moderately coarse textured and coarse textured soils, but it consists mainly of needle-and-thread, rabbitbrush, and big sagebrush. There are a few dense stands of bitterbrush and hopsage. Indian ricegrass and yellow wildrye (fig. 17) are grasses that help to stabilize active sand dunes and blowouts.

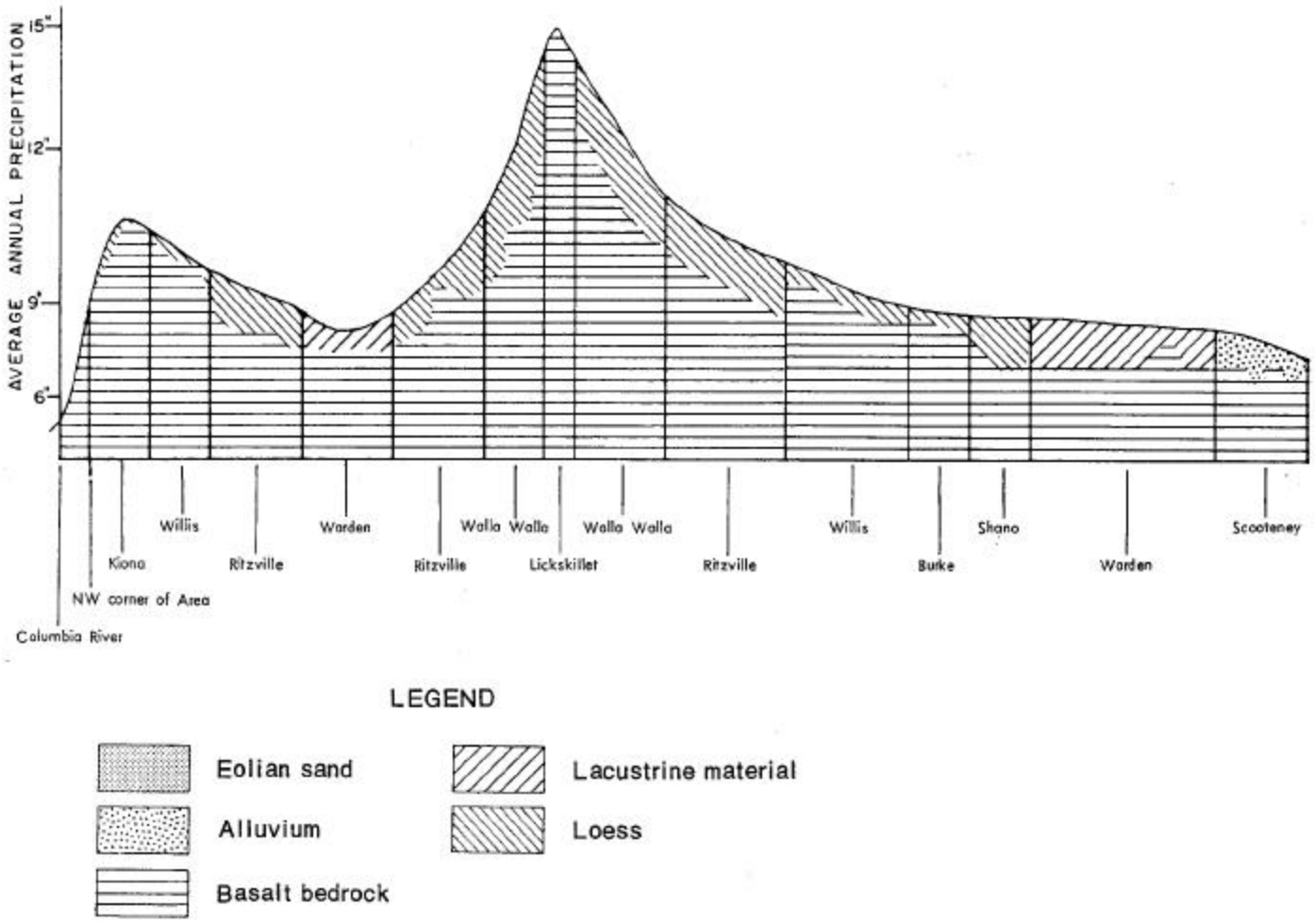


Figure 16.-Cross section of Benton County, showing the

Time

The length of time needed for the formation of a given kind of soil depends largely on the other factors of soil formation. Apparently, soil-forming factors have been acting on the parent material since the last glaciation, about 8,000 to 10,000 years ago. Under the prevailing climate, soil development has been minimal. In areas where annual precipitation is 6 to 9 inches, the application of irrigation water over the past fifty years has accelerated the development of soils so that some of the soils in these areas now have characteristics of soils that formed in a much wetter climate.

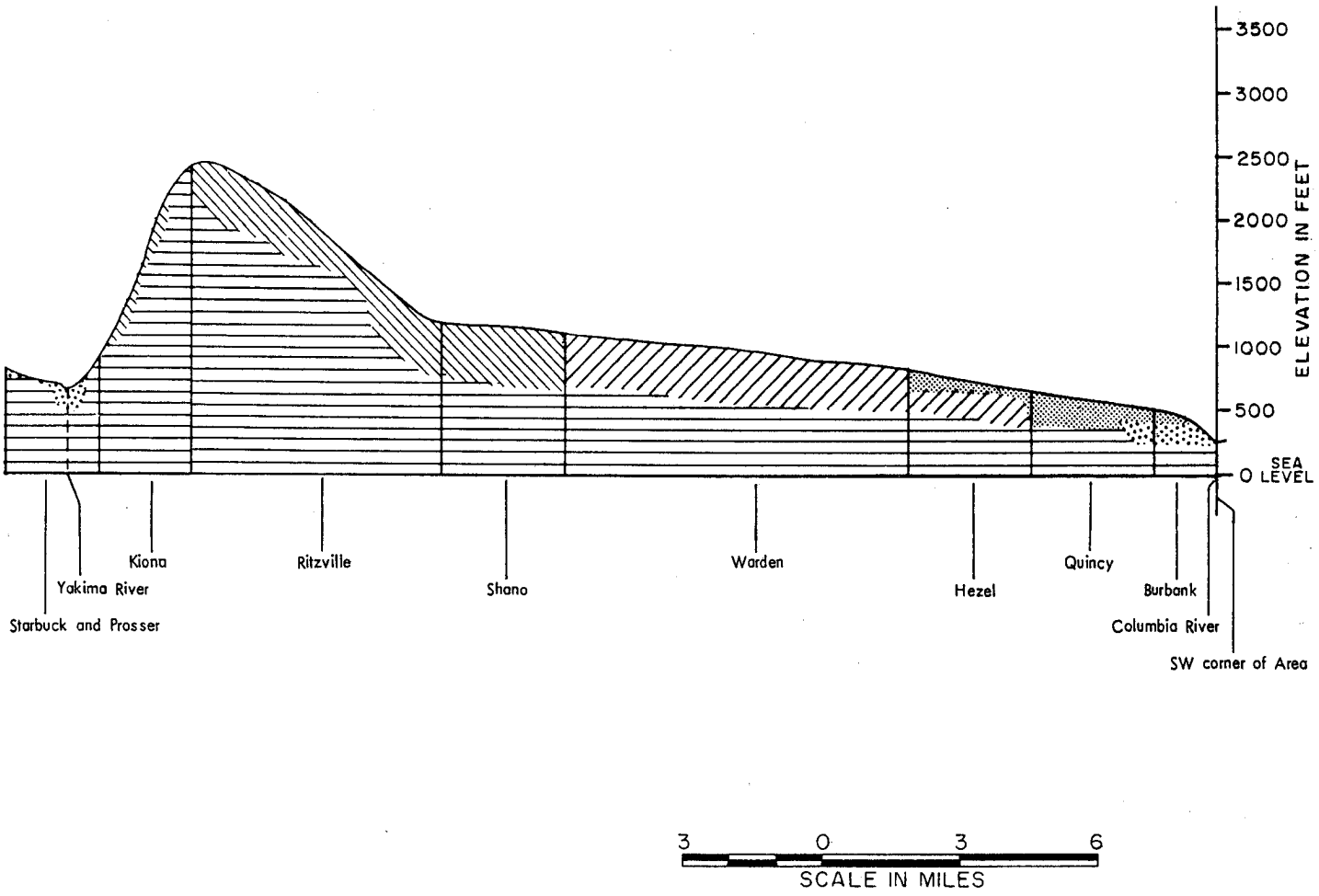
Classification of the Soils

Soil classification consists of a systematic grouping of soils on the basis of their characteristics. From such groupings it is possible to organize knowledge about defined kinds of soils and to apply the results of experience and research to areas that range in size from several acres to millions of acres.

Two systems of classifying soils have been used in the United States in recent years. The older system was adopted in 1938 (2) and later revised (11). The system currently used was adopted for general use by the National Cooperative Soil Survey in 1965 and supplemented in March 1967 (13). This system is under continual study, and readers interested in the development of the system should refer to the latest literature available (8).

The system of soil classification used in the United States before 1965 has six categories. Beginning with the most inclusive, the six categories are the order, the suborder, the great soil group, the family, the series, and the type. Only four of the categories-order, great soil group, series, and type-have been widely used.

In the highest category of the classification scheme are the zonal, intrazonal, and azonal orders. All three orders are represented in the Benton County Area. Seven of the great soil groups are represented: Sierozems, Brown soils, Chestnut soils, Low-Humic Gley soils, Solonchak soils, Alluvial soils, and Regosols. The relationship between the order, the great soil group, and the series is shown in table 9.



relationship of elevation, precipitation, and major soil series.

The system adopted in 1965 defines classes in terms of observable or measurable properties of soils. This system is designed to accommodate all soils. It has six categories, like the earlier system, but the categories are slightly different. Beginning with the most inclusive, they are the order, the suborder, the great group, the subgroup, the family, and the series. The classification of the soil series identified in this Area according to this system, also, is shown in table 9.

In this survey the classification of the soils is discussed in terms of the system used before 1965.

Zonal order

Soils of the zonal order have characteristics that reflect the influence of the active factors of soil genesis-climate and living organisms, chiefly vegetation. The zonal order is represented in the Benton County Area by three great soil groups: Sierozems, Brown soils, and Chestnut soils. These are discussed in the following paragraphs.

SIEROZEMS

Sierozem soils have a thin surface horizon underlain by a lighter colored subsoil and a layer of carbonate accumulation. In this Area these soils developed in loess, alluvium, and lacustrine deposits. The topography is nearly level to very steep. The elevation ranges from 300 to 1,300 feet. The annual precipitation is 6 to 9 inches, and the mean annual temperature is 50° to 51° F. The native vegetation consisted mainly of bunch grasses and sagebrush.

Soils of the Burke, Finley, Kennewick, Prosser, Scooteney, Shano, Starbuck, and Warden series are classified as Sierozems. All have weak, or minimal, development. Soils of the Burke, Kennewick, Prosser, Shano, and Warden series integrade toward Regosols; soils of the Finley and Scooteney series intergrade toward Alluvial soils; and soils of the Starbuck series intergrade toward Lithosols.

Soils of the Shano series are representative of the Sierozem great soil group. These soils formed in windblown deposits, the individual particles of which were mainly the size of silt grains. The principal evidences of soil development are the granular structure in the uppermost 6 inches and the slightly darker color of the uppermost 20 inches, which result from an accumulation of organic matter; the weak prismatic structure between depths of 6 and 20 inches. which result from alternate

Figure 17.-Initial stage in establishment of yellow wildrye to stabilize sand dunes. This grass spreads by underground roots.

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shrinking and swelling of the soil material; and the layer of carbonate accumulation below a depth of 28 inches. The particle-size distribution is nearly uniform throughout the profile. This uniformity indicates that the weathering of silt to clay and the downward movement of clay have been slight.

BROWN SOILS

Brown soils have a surface layer slightly thicker and darker than that of Sierozems. The surface layer is underlain by a lighter colored subsoil and a layer of carbonate accumulation. In this Area these soils developed mainly in loess or lacustrine sediments. The topography is nearly level to very steep. The elevation ranges from 800 to 2,500 feet. The annual precipitation is 9 to 12 inches, except on Kiona soils, where it is as little as 7 inches. The mean annual temperature is 48° to 50° F. The native vegetation consisted mainly of bunch grasses and sagebrush. Soils of the Ellisforde, Kiona, Ritzville, and Willis series are classified as Brown soils. All have weak, or minimal, development and intergrade toward Regosols.

Soils of the Ritzville series are representative of the Brown great soil group. These soils formed in silty, windblown deposits. Their surface layer is slightly darker colored and contains slightly more organic matter than that of Shano soils, which are members of the Sierozem great soil group. In addition, lime has been more deeply leached than in the Shano soils. These differences in properties reflect mainly the differences in the amount of precipitation and in the amount and kind of vegetation under which the soils formed.

CHESTNUT SOILS

Chestnut soils have a dark-colored surface layer, a lighter colored subsoil, and a layer of carbonate accumulation. In this Area these soils developed mainly in silty, windblown deposits or in windblown deposits mixed with basalt residuum. The topography is nearly level to very steep. The elevation ranges from 2,200 to 3,500 feet. The annual precipitation is 11 to 15 inches. The mean annual temperature is 47° to 48° F. The native vegetation consisted mainly of bunch grasses. Soils of the Endicott, Lickskillet, and Walla Walla series are classified as Chestnut soils. All have weak, minimal development. Soils of the Endicott and Walla Walla series intergrade toward Regosols, and soils of the Lickskillet series intergrade toward Lithosols.

Soils of the Walla Walla series are representative of the Chestnut great soil group. They differ from Shano soils, a member of the Sierozem great soil group, and from Ritzville soils, a member of the Brown great soil group, mainly in color and organic-matter content of the surface layer and in depth to lime. These differences in properties reflect mainly the differences in the amount of precipitation and the amount and kind of vegetation under which the soils formed.

Intrazonal order

Soils of the intrazonal order have characteristics that reflect the dominant influence of a local factor of relief or parent material over the effects of climate and vegetation. The intrazonal order is represented in the Benton County Area by two great soil groups: Low-Humic Gley soils and Solonchak soils. These are discussed in the following paragraphs.

LOW-HUMIC GLEY SOILS

Low-Humic Gley soils are somewhat poorly drained or poorly drained. These soils have a thin surface horizon that is moderately high in organic-matter content. The surface horizon is underlain by mottled gray or brown, gleyed, mineral horizons that show a low degree of textural differentiation. In this Area, Low-Humic Gley soils formed in alluvium and in silty, windblown deposits over gravelly alluvium. They occupy nearly level areas and slight depressions on terraces. The elevation ranges from 675 to 775 feet. The annual precipitation is 6 to 8 inches, and the mean annual temperature is 50° F. Soils of the Wamba series are classified as Low-Humic Gley soils.

In their natural state Wamba soils probably lacked gleyed horizons and mottles and probably had a lighter colored surface layer than they do now. The gleying and the mottles result from a deficiency of oxygen during periods when the soils were saturated, after irrigation was introduced some 50 years ago. Organisms that live in the soil obtain some of their oxygen from iron compounds which, along with organic matter, are the main coloring agents in soils. With the loss of oxygen, the iron compounds change from reddish or yellowish to gray or green and become soluble. Some of the soluble iron has been removed in drainage water. As the soil periodically dries out, some of the iron reogidizes and becomes segregated and the bright-colored mottles form. Wamba soils have some free lime in the surface layer because more lime has been added in the irrigation water than has been leached away.

SOLONCHAK SOILS

Solonchak soils have a high concentration of soluble salts. These soils are ordinarily light colored and have weak structure or none at all. They developed under salt-tolerant grasses or shrubs, mainly in an arid, semiarid, or subhumid climate. In the Benton County Area, Solonchak soils formed in alluvium on bottom lands. The topography is nearly level. The elevation ranges from 250 to 1,000 feet. The annual precipitation is 6 to 9 inches. The mean annual temperature is 50° F. Soils of the Umapine series are classified as Solonchak soils.

The principal evidences of soil development are the accumulation of lime, salts, and alkali throughout the profile and faint mottles below a depth of 3 inches. The parent material probably was nearly neutral, noncalcareous or only slightly calcareous, and free or nearly free of soluble salts and alkali. Seepage, which brought in dissolved salts, sodium, and lime from adjacent soils, is responsible for the present chemical properties of the soils, and periodic saturation has brought about the mottling.

Azonal order

Soils of the azonal order lack well-developed profile characteristics because of their youth, resistant parent material, or relief. The azonal order is represented in the Benton County Area by the Alluvial and Regosol great soil groups. These are discussed in the following paragraphs.

ALLUVIAL SOILS

Alluvial soils develop in water-transported, recently deposited material, or alluvium, that has undergone little or no modification by soil-forming processes. The characteristics of Alluvial soils depend largely on the nature of the parent material. The Alluvial soils in Benton County formed in material derived mainly from loess and lake sediments. They are nearly level to gently sloping. The elevation ranges from 250 to 1,400 feet. The annual precipitation is 6 to 12 inches, and the mean annual temperature is 50° to 53° F. The native vegetation consisted of bunch grasses, sedges, saltgrass, and willows. Soils of the Esquatzel and Pasco series are classified as Alluvial soils.

Soils of the Esquatzel series are representative of the Alluvial great soil group. Evidence of soil development is lacking except for the weak structure and slightly darker color of the uppermost 11 inches, which is a result of an accumulation of organic matter. In addition, the higher pH value and effervescence in the C horizon indicate that bases, including calcium carbonate, have been leached from the upper layers by rainwater.

REGOSOLS

Regosols develop in thick, unconsolidated rock material or soft mineral deposits. Few or no clearly expressed horizons have formed. As is the case with Alluvial soils, the characteristics of Regosols depend largely on the nature of the parent material. The Regosols in Benton County formed mainly in windblown sands that are underlain in places by gravelly or stony alluvium, lacustrine sediments, or a hardpan. The slope ranges from nearly level to very steep, and the elevation from 300 to 1,100 feet. The annual precipitation is 6 to 8 inches, and the mean annual temperature is 51° to 53° F. The native vegetation consisted mainly of grass and sagebrush. Soils of the Burbank, Hezel, Koehler, and Quincy series are classified as Regosols.

Soils of the Quincy series are representative of the Regosol great soil group. The principal evidence of soil development is the lower pH value in the uppermost part of the soil. This fact indicates that some bases have been removed by leaching and have been replaced by hydrogen. In addition, a layer of lime accumulation begins at a depth of 40 inches.

Additional Facts About the Area

The Benton County Area covers about three-fourths of Benton County. The northeastern part was excluded from the survey. The first inhabitants of this Area were Indians who lived on the banks of the Yakima and Columbia Rivers. Artifacts from this early period can still be found along the river banks.

In 1805 the Lewis and Clark expedition passed through, and fur traders, trappers, and settlers followed in succeeding years. The first settler's cabin was built near the mouth of the Yakima River in 1863.

Benton County was established by legislative act on March 8, 1905, with Prosser as the county seat. The county was created from parts of Yakima and Klickitat Counties.

In 1910 the population of Benton County was 7,937. By 1960 it had reached 62,070.

Farming

Before 1890 the climate of Benton County was considered too dry for farming. The only settlements were those of stockmen, who lived near rivers where their stock could graze and find water. Large herds of wild horses roamed throughout the county. Grazing cattle and horses was the principal enterprise until after 1900.

In 1892 irrigation canals were constructed on both sides of the Yakima River. One canal led to Kennewick, and another to Richland. Today, irrigation is an important part of the farming economy. There are many irrigation districts in the Area where farmers can use irrigation water from the Yakima River. There are a few farms where the water comes from privately owned wells or directly from the Yakima or Columbia Rivers; at each point of withdrawal the user has obtained water rights. All irrigation water is of good quality.

In 1959 irrigated crops were harvested from 1,141 farms, covering 55,283 acres. The most common irrigation methods are by furrow or corrugation. Alfalfa, asparagus, corn, grapes, hops, mint, orchard crops, pasture, peas, potatoes, and sugar beets are the principal irrigated crops.

Dryland farming was begun about 1900 in the Horse Heaven Hills. Wheat and rye were the main crops. The soil was plowed with a moldboard plow, and the wheat was cut with wooden combines pulled by 30 to 36 horses. Yields of 6 to 10 bushels per acre were considered good. Crop failures were frequent.

Better equipment and improved moisture-conservation practices have contributed to better yields of dryland crops. Wheat, barley, and rye are the principal unirrigated crops.

Industry

Industries in the Area are mainly those related to farming. They include facilities for canning, freezing, and storing vegetables, fruits, and juice concentrates; large grain elevators; and manufacturing plants where fertilizer and chemicals for agricultural use are produced.

In addition, hydroelectric power plants on the Columbia River provide power for industry. Ocean-barge transportation is available through a network of canals and slack-water routes created by impounding water behind dams. An almost unlimited supply of natural gas is available through an existing pipeline. Three railroads serve the Area, and there is a good system of highways.

Climate

The climate of the Benton County Area has both marine and continental characteristics. It is influenced by moist air moving in from the Pacific Ocean and by cold air moving southward from Canada. The weather systems are modified by the Rocky Mountains to the east and north and by the Cascade Mountains to the west.

The summers are hot, and the winters are clear, dry,

By EARL L. PHILLIPS, State climatologist, U. S. Weather Bureau, Seattle.

and cold. Occasional cold snaps late in spring or early in fall cause extensive damage to crops. Tables 10, 11, 12, 13, 14, 15, and 16 give data on temperature and precipitation, probability of low temperatures, precipitation means and extremes, evapotranspiration, and evaporation and wind movement.

In summer the afternoon temperature reaches the nineties, and the nighttime temperature falls to about 60° F. In an average summer, the temperature exceeds 90° on 50 to 60 days and 100° on 8 to 12 days. The relative humidity ranges from approximately 50 percent at sunrise to about 25 percent in the afternoon.

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In winter the afternoon temperature reaches the thirties, and the nighttime temperature falls to about 20° F. The relative humidity ranges from approximately 85 percent at night to about 75 percent in the afternoon. In an average winter, the maximum temperature is below freezing on 20 to 30 days, and the minimum is below zero on two to five nights. In some of the colder winters, the temperature falls below zero on 10 to 20 nights. In January, normally the coldest month, the temperature can be expected to drop to zero or below on one or more nights in three out of ten winters, to 10° below zero or lower in two out of ten winters, and to 20° below zero in one out of ten winters. On clear, calm nights the minimum temperature in the valleys is frequently 5° to 10° below that on adjacent hills. Occasionally, a chinook wind brings a rapid rise in temperature.

The lower elevations of Benton County are in the driest part of eastern Washington. Moist air moving inland from the Pacific cools as it rises over the western slopes of the Cascade Mountains and becomes warmer and drier as it descends along the eastern slopes. These weather systems bring heavy precipitation along the windward slopes, but lighter precipitation along the lee slopes. At the lower elevations the annual precipitation is 7 or 8 inches; it gradually increases to 10 inches or more over Horse Heaven Hills and the Rattlesnake Hills.

Fall rains begin about the first of October. Precipitation gradually increases late in fall, reaches a peak of 1 to 1 1/4 inches each month in winter, then gradually decreases in spring, increases again in June, and then decreases sharply in July.

Thunderstorms can be expected on 1 to 3 days each month from March through September. Occasionally, severe thunderstorms develop over the ridges and move across the valleys.

Snowfall in winter usually amounts to 10 to 20 inches. In about 1 year in 20, it totals 30 to 40 inches. Snow seldom accumulates to a depth of more than 6 to 10 inches

or stays on the ground longer than 2 to 4 weeks. In unusually severe winters snow is on the ground most of the time from late in December until early in February. Frost penetrates to a depth of 10 to 15 inches nearly every winter and to a depth of 20 to 30 inches in extremely cold winters.

The following number of days with measurable precitation can be expected each year: 0.01 of an inch or more on 60 to 80 days, 0.10 of an inch or more on 20 to 35 days, and 0.50 of an inch or more on 6 to 10 days. Measurable rainfall can be expected 1 to 2 days each month in summer and 8 to 15 days each month in winter.

The percentage of possible sunshine each month ranges from 20 to 30 percent in winter; from 50 to 60 percent in spring and fall; and from 80 to 90 percent in summer. The number of clear days each month is less than 5 in winter but more than 20 in summer. There is considerable fog and cloudiness in winter. Heavy fog can be expected on five to ten nights each month.

Techniques developed by Palmer-Havens for application of the Thornthwaite method (1948) (10) were used in arriving at the estimates of potential evapotranspiration shown in table 15. Evapotranspiration is the combined loss of moisture by evaporation from the soil and by transpiration through the leaves and stems of plants. Potential evapotranspiration is an estimate of the amount of moisture that will be lost from a soil that has a good cover of growing, grasslike plants. Actual evapotranspiration is the actual amount. of moisture lost; it is usually the same as annual precipitation, less any runoff that may occur. Actual evapotranspiration cannot exceed potential evapotranspiration.

The prevailing winds are from the west and northwest, but the strongest are from the southwest. The average velocity for a month ranges from approximately 6 miles per hour in winter to 9 miles per hour in summer. In winter there is very little diurnal variation in windspeed, but in summer there is a noticeable increase in wind velocity late in the afternoon. At 30 feet above the ground wind velocities can be expected to reach 50 miles per hour at least once in 2 years, 60 to 75 miles per hour once in 50 years, and 80 miles per hour once in 100 years.

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Glossary

Aggregate, soil. Many fine particles held in a single mass or cluster. Natural soil aggregates such as crumbs, blocks, or prisms, are called peds. Clods are aggregates produced by tillage or logging.

Alkali soil. Generally, a highly alkaline soil. Specifically, an alkali soil has so high a degree of alkalinity (pH 8.5 or higher) or so high a percentage of exchangeable sodium (15 percent or more of the total exchangeable bases), or both, that the growth of most crop plants is low from this cause.

Alluvium. Soil material, such as sand, silt, or clay, that has been deposited on land by streams.

Available water capacity. The capacity of a soil to hold water in a form available to plants. Amount of moisture held in soil between field capacity, or about one-third atmosphere of tension, and the wilting coefficient, or about 15 atmospheres of tension. The ratings are low, less than 3.75 inches; moderate, 3.75 to 5 inches; moderately high, 5 to 7.5 inches; high, more than 7.5 inches. Soils of low capacity require frequent but light irrigations, using a large head of irrigation water and short runs. Soils of high capacity can be irrigated less frequently with large quantities of water, using a smaller head and longer runs.

Blowout. An area from which soil material has been removed by wind. Such an area appears as a nearly barren, shallow depression with a fiat or irregular floor consisting of a resistant layer, an accumulation of pebbles, or wet soil lying just above a water table.

Bottom land. Low land formed by alluvial deposits along a river; a flood plain.

Calcareous soil. A soil containing enough calcium carbonate to effervesce (fizz) visibly when treated with cold, dilute hydrochloric acid.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are-

Loose.-Noncoherent when dry or moist; does not hold together in a mass.

Friable.-When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

Firm.-When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Plastic.-When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger.

Sticky.-When wet, adheres to other material and tends to stretch somewhat and pull apart, rather than to pull free from other material.

Hard.-When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Soft.-When dry, breaks into powder or individual grains under very slight pressure.

Cemented.-Hard and brittle; little affected by moistening.

Contour farming. Following the contour of the land in plowing, planting, and cultivating.

Cover crop. A close-growing crop grown primarily to improve and to protect the soil between periods of regular crop production; or a crop grown between trees and vines in orchards and vineyards.

Depth, soil. Effective depth to which plant roots can readily penetrate without being inhibited by a layer of hardened lime, a claypan, gravel, stones, or bedrock. In this survey the depth classes are (1) very shallow, 0 to 10 inches; (2) shallow, 10 to 20 inches; (3) moderately deep, 20 to 36 inches; and (4) deep, 36 to 60 inches or more.

Drainage class. The relative terms used to describe natural drainage are explained as follows

Excessively drained soils are commonly very porous and rapidly permeable, and have low water-holding capacity.

Somewhat excessively drained soils are rapidly permeable and are free from mottling throughout the profile.

Well-drained soils are nearly free of mottling and are commonly of moderately coarse to moderately fine texture.

Moderately well drained soils commonly have a slowly permeable layer in or immediately beneath the solum. They have uniform color in the A horizon and the upper part of the B horizon and mottling in the lower part of the B horizon and in the C horizon.

Somewhat poorly drained soils are wet for significant periods but not all the time. They commonly have a slowly permeable layer in the profile, a high water table, or they receive seepage.

Poorly drained soils are wet for long periods of time. Most of these soils are light gray and are generally mottled from the surface downward.

Very poorly drained soils are wet nearly all the time. They generally have a dark-gray or black surface layer and are gray or light gray, with or without mottling, in the deeper part.

Dryfarming. Producing crops that require some tillage in a semiarid region without irrigation. The system usually requires periods of fallow between crops, and during these periods water from precipitation is absorbed and stored in the soil.

Erosion. The wearing away of the land surface by wind (sandblast), running water, and other geological agents.

Erosion hazard. Susceptibility to wind or water erosion. The terms used in this survey are slight, moderate, severe and very severe. These terms are relative and apply only in relation to other soils of the Denton County Area.

Fallow. Cropland left idle in order to restore productivity, mainly through accumulation of water, nutrients, or both. The soil is tilled but not planted for at least one growing season to control weeds, to aid decomposition of plant residue, and to encourage the storage of moisture for the succeeding grain crop.

Fertility, soil. The quality of a soil that enables it to provide compounds, in adequate amounts and in proper balance, for the growth of specified plants, when other growth factors such as light, moisture, temperature, and the physical condition of the soil are favorable.

Green-manure crop. Any crop grown and plowed under to improve the soil by the addition of organic matter.

Head, irrigation. The difference in elevation of the irrigation water supply; therefore, the pressure at the point of discharge.

Horizon, soil. A layer of soil, approximately parallel to the surface that has distinct characteristics produced by soil-forming processes. These are the major horizons

0 horizon.-The layer of organic matter on the surface of a mineral soil. This layer consists of decaying plant residues.

A *horizon*.-The mineral horizon at the surface or just below an O horizon. This horizon is the one in which living organisms are most active and therefore is marked by the accumulation of humus. The horizon may have lost one or more of soluble salts, clay, and sesquioxides (iron and aluminum oxides).

B horizon.-The mineral horizon below an A horizon. The B horizon is in part a layer of change from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics caused (1) by accumulation of clay, sesquioxides, humus or some combination of these; (2) by prismatic or blocky structure; (3) by redder or stronger colors than the A horizon; or (4) by some combination of these. Combined A and B horizons are usually called the solum, or true soil. If a soil lacks a B horizon, the A horizon alone is the solum.

C horizon.-The weathered rock material immediately beneath the solum. In most soils this material is presumed to be like that from which the overlying horizons were formed. If the material is known to be different from that in the solum, a Roman numeral precedes the letter C.

R layer.-Consolidated rock beneath the soil. The rock usually underlies a C horizon but may be immediately beneath an A or B horizon.

Irrigation. The artificial application of water to soils to assist in the production of crops. The common methods of irrigation are these:

Border. Water is applied at the upper end of a strip in which the lateral flow of water is controlled by small earth ridges called border dikes, or borders.

Corrugation. Water is applied to small, closely spaced furrows or ditches in fields of close-growing crops or in orchards to confine the flow of water -to one direction.

Controlled flooding. Water is released at intervals from closely spaced field ditches and distributed uniformly over the field.

Furrow. Water is applied in small ditches made by cultivation implements used for tree and row crops.

Sprinkler. Water is sprayed over the soil surface through pipes or nozzles from a pressure system.

Subirrigation. Water is applied in open ditches or tile lines until the water table is raised enough to wet the soil.

Lacustrine deposits (geology). Material deposited in lake water and exposed by lowering of the water level or by elevation of the lakebed.

Loess. Fine-grained, windblown deposits, mainly of silt-sized particles.

Mottled. Irregularly marked with spots of different colors that vary in number and size. Mottling in soils usually indicates poor aeration and lack of drainage. Descriptive terms are as follows: Abundance-*few, common,, and many; size-fine, medium, and coarse*; and *contrast-faint, distinct, and prominent.* The size measurements are these: *fine,* less than 5 millimeters (about 0.2 inch) in diameter along the greatest dimension; *medium,* ranging from 5 millimeters to 15 millimeters (about 0.2 to 0.6 inch) in diameter along the greatest dimension; and *coarse,* more than 15 millimeters (about 0.6 inch) in diameter along the greatest dimension.

Permeability. The quality of a soil horizon that enables water or air to move through it. Terms used to describe permeability are as follows: very slow, slow, moderately slow, moderate, moderately rapid, rapid, and very rapid.

Profile, soil. A vertical section of the soil through all its horizons and extending into the parent material.

Reaction, soil. The degree of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is precisely neutral in reaction because it is neither acid nor alkaline. An acid, or "sour," soil is one that gives an acid reaction; an alkaline soil is one that is alkaline in reaction. In words, the degrees of acidity or alkalinity are expressed thus

	pH		*pH*
Extremely acid--------	Below 4.5	Neutral ----------	6.6 to 7.3
Very strongly acid----	4.5 to 5.0	Mildly alkaline---------	7.4 to 7.8
Strongly acid----------	5.1 to 5.5	Moderately alkaline---	7.9 to 8.4
Medium acid----------	5.6 to 6.0	Strongly alkaline-------	8.5 to 8.0
Slightly acid----------	6.1 to 6.5	Very strongly alkaline-	9.1 and higher

Saline-alkali soil. A soil that contains a harmful concentration of salts and either a high degree of alkalinity or a large amount of exchangeable sodium, or both.

Sand. Individual rock or mineral fragments in soils having diameters ranging from 0.05 to 2.0 millimeters. Most sand grains consist of quartz, but they may be any mineral composition.

The textural class name of any soil that contains 85 percent or more sand and not more than 10 percent clay.

Silt. Individual mineral particles in a soil that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). Soil of the silt textural class is 80 percent or more silt and less than 12 percent clay.

Slope. The incline of the surface of a soil, usually expressed in percentage terms that equal the number of feet of fall per 100 feet of horizontal distance. In this publication slope is expressed as follows

Nearly level----------0 to 2 percent.
Gently sloping----------2 to 5 percent.
Moderately sloping----------5 to 8 percent.
Strongly sloping----------8 to 15 percent.
Moderately steep----------15 to 30 percent.
Steep ----------30 to 65 percent.
Very steep----------65 percent or more.

Structure, soil. The arrangement of primary soil particles into compound particles or clusters that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. The principal forms of soil structure are-*platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular*. Structureless soils are (1) single grain. (each grain by itself, as in dune sand) or (2) massive (the particles adhering together without any regular cleavage, as in many claypans and hardpans).

Subsoil. Technically, the B horizon; roughly, the part of the solum below plow depth.

Subsurface tillage. Tillage with a sweeplike plow or blade that does not turn over the surface cover or incorporate it into the lower part of the surface soil.

Surface soil. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, about 5 to 8 inches in thickness. The plowed layer.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, *are sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay, and clay*. The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."